POWER

Volume 58 New York, September 4, 1923 *Number* 10

The N. A. S. E.

SINCE the National Association of Stationary Engineers met at Des Moines a year ago, two of its founders have passed away—Henry D. Cozens, its first president, and James G. Beckerleg, his immediate successor.

They lived to see the organization which they started in 1882 develop until today it has over twenty thousand members and includes many of the outstanding power-plant engineers of the country.

They belong to the N.A.S.E., not because they are successful engineers, but are successful engineers because they belong to the N.A.S.E.

Not simply because they belong to it, for not all the members are conspicuously successful, but because they make the most of the advantages that it offers.

The N.A.S.E. was founded upon the natural propensity of the engineer to talk engineering, his love for discussion and his hunger for engineering knowledge.

The live and progressive among the local associations are those in which this propensity is cultivated and this appetite ministered to.

When a member comes to a meeting and finds but a handful there, sits through the ritual and gets nothing out of it that appeals to his engineering interest or adds to his engineering knowledge, he has to be of a peculiar make-up to persist.

Some come because they are or hope to be officers, some from loyalty and fraternalism, but the new member who has been attracted by the alleged educational advantages fails to find satisfaction. The association loses its power to recruit its ranks or to attract worth-while lecturers and passes out or drags on with barely enough vitality to hold its charter and afford somebody a chance to go, as its delegate, to the national convention.

Fortunate is the association that has a live program or educational committee; that realizes that the order of business is only the form or skeleton of a meeting and that something more than a perfunctory performance of it is necessary to fulfill the promises that the association offers or to realize its opportunities of service to industry and to the craft.

There are many engineers who ought to be members of the N.A.S.E. and are not. They would be, if its meetings furnished that of which they feel the need.

Make your meetings attractive, interesting and instructive and the association will grow like a green bay tree.

New Mac-Sim-Bar Boiler Plant Saves $100,000 per Year

A SAVING ranging from $75,000 to $100,000 per year or nearly $2 for every ton of board produced has been effected by the Mac-Sim-Bar Paper Company at Otsego, Mich., by the installation of a new boiler plant. The new installation has been in operation for several months and operating figures now available show that the consumption of coal per ton of board has been reduced from 2,200 lb. to about 1,200 lb. At the same time the production of board for a 24-hour day has been increased from 150 tons to 170 tons and the power-house payroll has been cut in two.

This saving has been effected in the boiler room, as the six engines of various types, driving the mills, the overhead shafting and mechanical drives have been retained. At an early date, however, it is the intention to erect a central generating room adjacent to the boiler house, and equip it with either turbine- or engine-driven units which will operate non-condensing in order that the exhaust steam may be available for drying. The shafting and mechanical drives will be removed and the mill machinery operated electrically. With this additional improvement it is expected that the coal consumption per pound of board will be reduced to ½ lb., as compared with the average mill requirement of ¾ lb. of coal per pound of board.

As an explanation of the large saving in coal, it should be explained that the old plant contained ten water-tube boilers of three different types, which had been installed from time to time as dictated by the requirements of the mill. The boilers were equipped with top-feed stokers, a single economizer serving the plant and induced-draft fans to draw the gases through the economizer. Part of the equipment was old and worn out, so that the upkeep was excessive and due to the irregularity of the general layout, caused by the installation of vertical, horizontal and bent-tube boilers, the labor of handling coal and ash was much greater than a uniform plant would have required.

The heavy labor requirements coupled with the poor economy obtainable from the plant as a whole, made it desirable to erect a new boiler house laid out for the automatic handling of coal and ash. The new boiler house was built adjacent to the old one and as soon as it was completed, the old one was torn down and on its site was excavated a coal-storage pit served by two tracks.

The new building is 136 ft. long and 66 ft. wide. The basement height is 12 ft. and from the boiler-room floor to the bottom roof girder, the elevation is 47 ft. The building is of tapestry brick and steel construction with Bedford stone trimmings. A large monitor with six 48-in. suction ventilators on the roof runs the full length of the building, insuring a light interior and thorough ventilation over the boilers. A feature is an elaborate system of steel runways giving access to all parts of the plant.

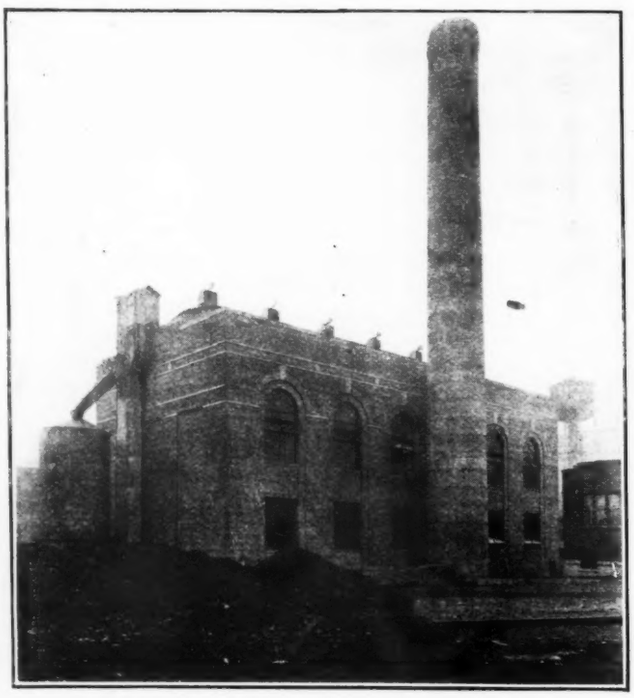


FIG. 1—NEW BOILER PLANT OF MAC-SIM-BAR PAPER CO.

From the numerous illustrations, a good idea will be obtained of the arrangement of the equipment installed. The plant contains six 5,000-sq.ft. vertical water-tube boilers set singly and installed on the unit plan. Each boiler has its independent forced-draft fan, induced-draft fan, coal scale and individual economizer. Each fan is engine-driven, belts being employed with the forced-draft fans and direct drive for the induced-draft fans. High economy, low first cost, ease of regulation and a speed more nearly conforming to that of the fan, are the reasons given for the selection of this type of prime mover. These engines were designed specially for operation at high pressures and superheats. At present the operating conditions are: steam pressure, 150 lb.; superheat, 125 deg.; back pressure, 10 lb. Later the pressure is to be raised to 200 lb., the other conditions remaining the same. The features include a special throttle governor and throttle valve, metallic packing on the piston rod and valve stem and force-feed lubrication.

Underfeed stokers of the central retort type set in dutch ovens, serve the boilers. Steam is generated at 175 lb. and superheated 125 deg. Normal operation is at about 165 per cent of rating with occasional peaks up to 200 per cent. Five boilers are maintained in continuous operation night and day by three operating shifts, leaving one boiler in reserve for cleaning or emergency use.

With boilers of the vertical two-pass type, the gas outlet is near the bottom of the setting, so that the economizers are placed at the floor level. They are of the new counter-flow type made up of steel tubes surrounded by cast-iron fins. Water jets are employed to remove the soot. The feed water leaves the economizer at a temperature slightly exceeding 300 deg., which is approximately 100 deg. higher than the temperature of the feed water leaving the heater.

From the various boilers the smoke flues have been set low to serve as bases for the induced-draft fans. The flues are made of concrete, lined with firebrick.

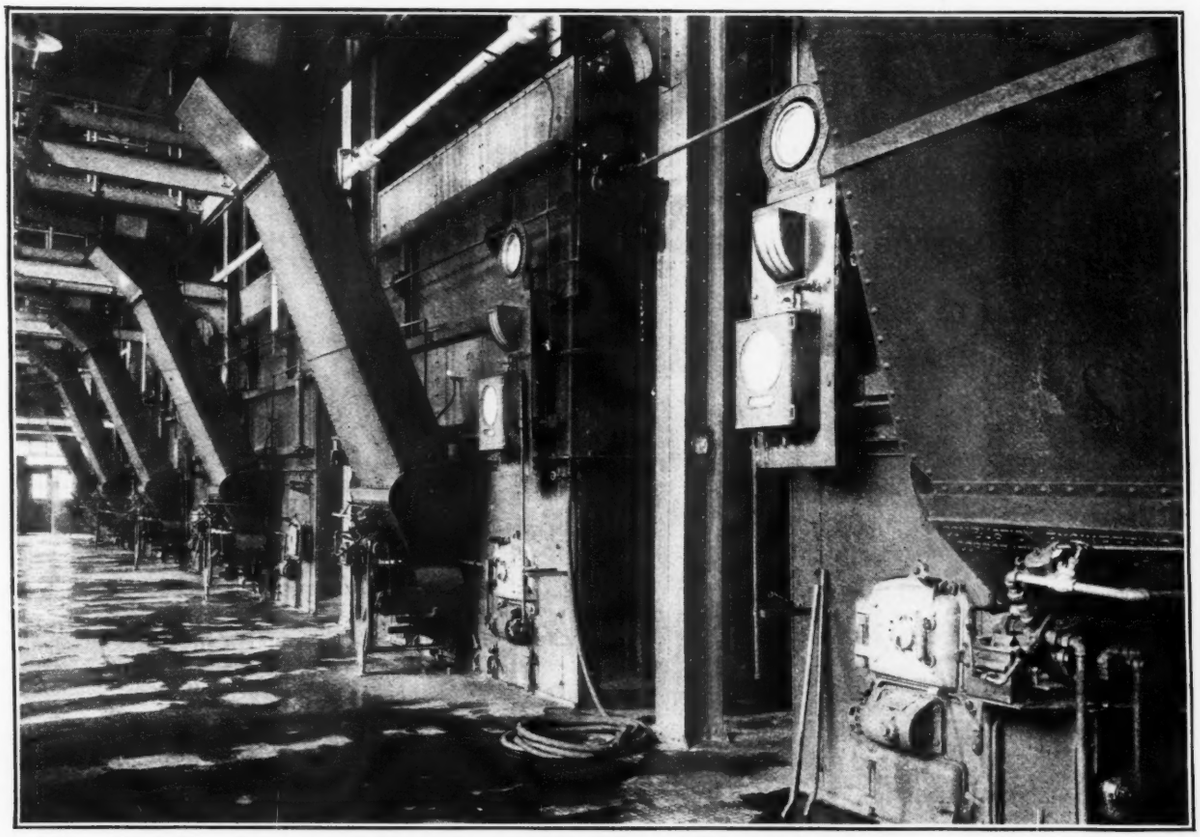


FIG. 2—LOOKING DOWN AISLE OF THE BOILER ROOM

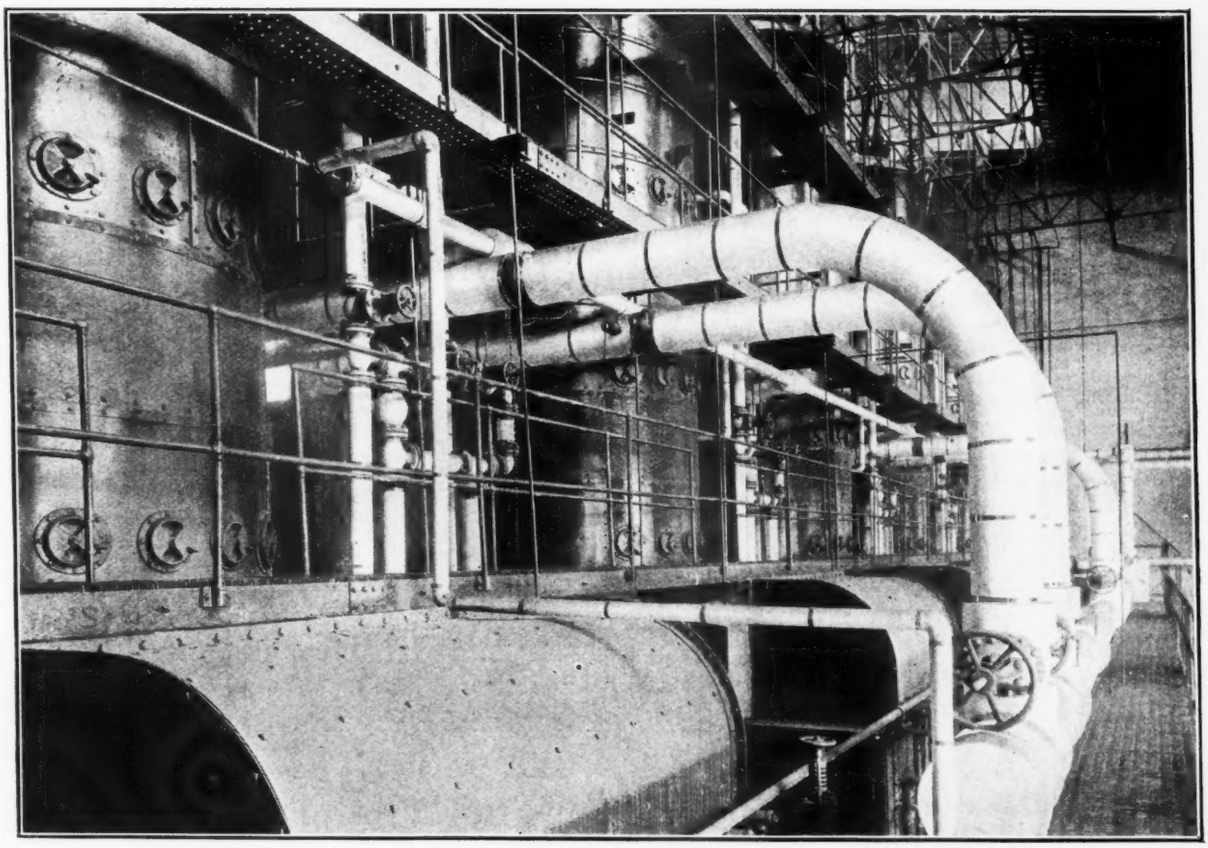


FIG. 3—REAR VIEW OF BOILERS SHOWING ECONOMIZERS AND STEAM HEADER

and, as indicated in Fig. 12, the three flues on either side of the center line of the boiler room converge into a common flue leading into one side of the stack. At the center of the stack, an 8-in. brick wall, 12 ft. high, separates the gas currents from the two opposing flues

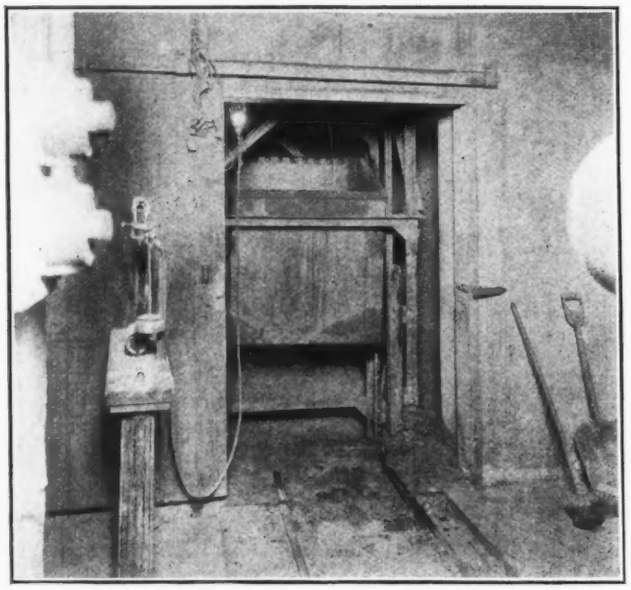


FIG. 4—SCALES FOR WEIGHING ASH

and prevents interference one with the other. The stack is of reinforced concrete, 175 ft. high above the base.

From the railway siding along the boiler room, the coal is dumped into a track hopper and by means of an inclined conveyor delivered through a crusher to a continuous bucket conveyor making a circuit over the overhead bunker, which has capacity to store 500 tons of coal. As indicated in Fig. 7 the V-shaped spouts of box cross-section, wide at the bunker and converging to a limited area at the other end, discharge into individual automatic coal scales in which the coal to the stoker is weighed.

From the hoppers under the stokers the ashes are delivered through counterbalanced gates into industrial cars running on tracks. On a platform scale, shown in Fig. 4, the ashes are weighed before transfer is made to a skip hoist delivering into an elevated tank made of hollow, glazed, vitreous tile. The tank is arranged for gravity delivery to trucks.

As feed water, all returns from the mill are brought back to the plant and pass through a grease extractor before delivery to a large open feed-water heater which receives the exhaust of the fan engines and raises the temperature of the water to approximately 200 deg. F. Make-up water under float control is admitted to the heater from a cold process water softening plant installed to serve the older station. The supply comes from the Kalamazoo River. As a reserve supply, two wells have been sunk on the property and storage maintained in two large overhead tanks. Feed-water pumping facilities consist of two single direct-acting pumps and as a reserve unit a turbine-driven centrifugal pump has been installed.

Full Line of Instruments Affords Complete Operating Data

In order that full operating data might be available, the plant has a full complement of instruments. There is an individual automatic coal scale for each stoker to weigh the coal as it is fed to the boiler and the ashes are weighed on a platform scale as they pass into storage. Each boiler has a steam flow meter and other flow meters measure the total boiler output and the steam used for the production of board. Three-in-one draft gages register the air pressure under the fire,

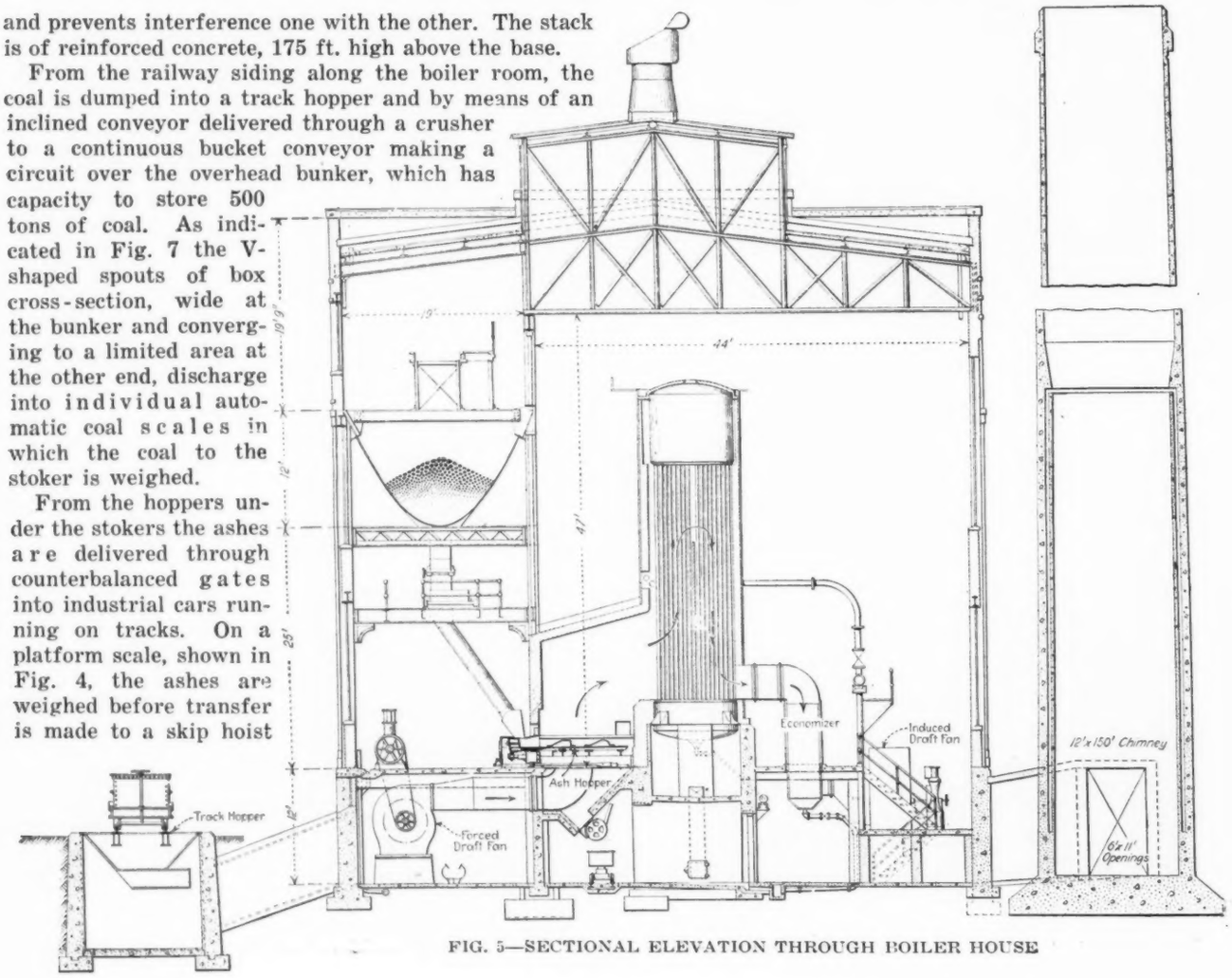


FIG. 5—SECTIONAL ELEVATION THROUGH BOILER HOUSE

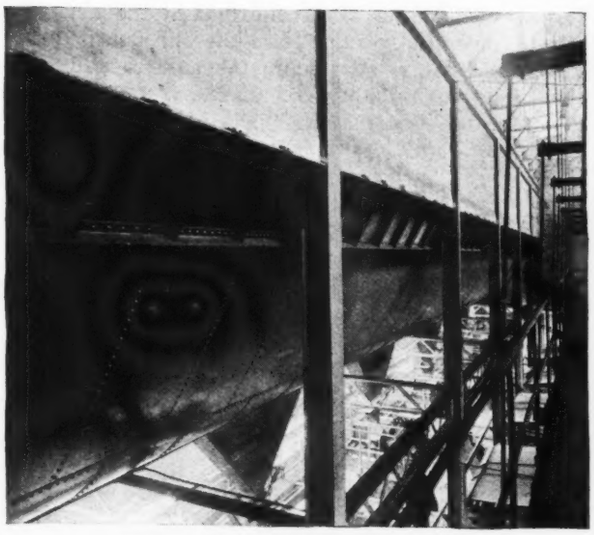


FIG. 6—OVERHEAD COAL BUNKER

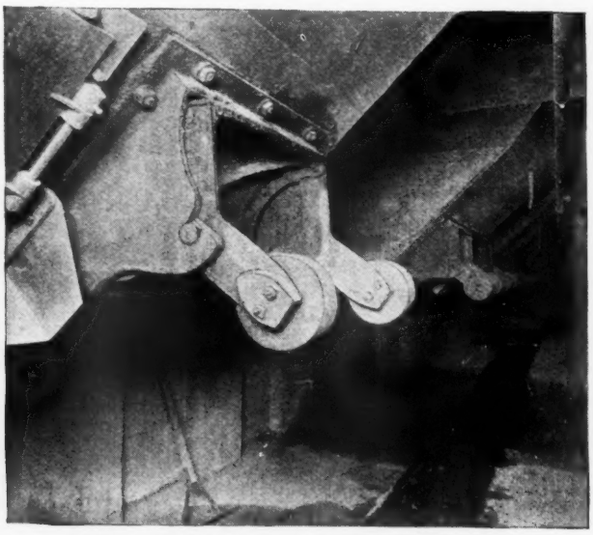


FIG. 9—COUNTER-BALANCED ASH GATES

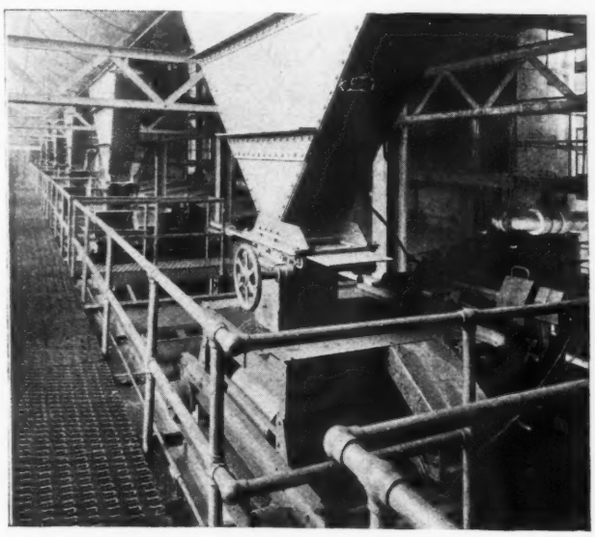


FIG. 7—AUTOMATIC COAL SCALES

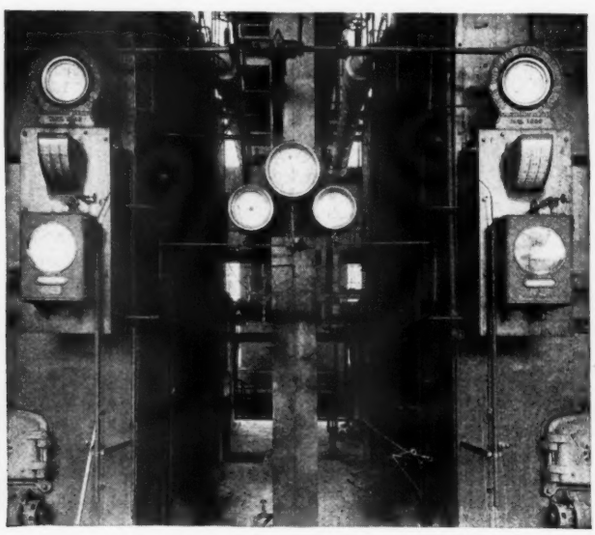


FIG. 10—INSTRUMENT PANELS ON BOILER FRONTS

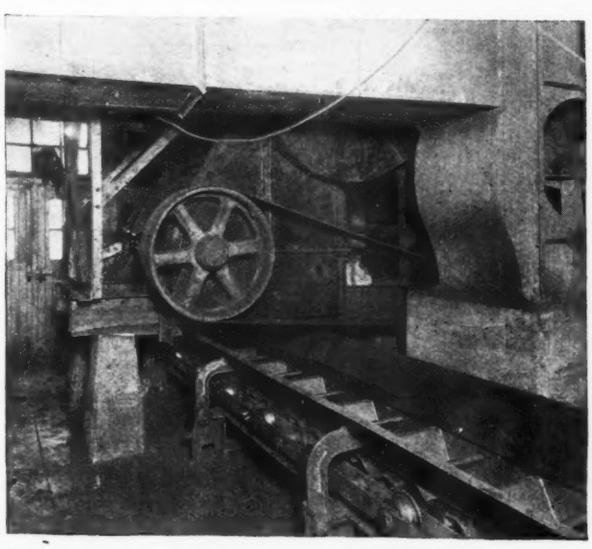


FIG. 8—COAL CRUSHER AND CONTINUOUS CONVEYOR

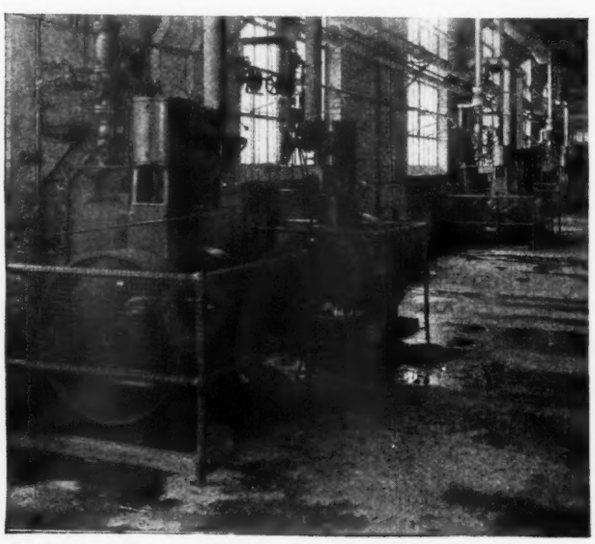


FIG. 11—ENGINES BELTED TO FORCED-DRAFT FANS

over the fire and at the boiler outlet. On each economizer multiple temperature gages show the entering and the leaving temperatures of both the gas and the water.

Plans and specifications for the new boiler plant were prepared by Billingham & Cobb, of Kalamazoo, paper mill architects and engineers, in co-operation with Charles E. Nelson, president of the Mac-Sim-Bar Paper Company. Mr. Nelson has always been an exponent of the belief that the cost of board begins at the coal pile and his decision has been confirmed by the large savings effected over the results from the old plant. This is a viewpoint that is now being taken more and more by the executives of industrial plants, and what has been done in this instance will point the way to possible savings in many other plants.

DATA ON MECHANICAL EQUIPMENT OF MAC-SIM-BAR BOILER PLANT

GENERAL

Plant location	Otsego, Mich.
Boilers installed	6
Heating surface per boiler, sq.ft.	5,083
Auxiliaries	Engine driven
Nature of load	Power and steam loads in board mill
Length of boiler room, inside	133 ft.
Width of boiler room, inside	62 ft. 9 in.
Boiler heating surface per sq.ft. of floor area	3.65

BOILERS

Manufacturer	Wickes Boiler Co.
Type	Vertical water tube
Heating surface	5,083 sq.ft.
Grate area, projected	90 sq.ft.
Boiler heating surface, per sq.ft. of grate area	56.48 sq.ft.
Working pressure	175 lb. gage
Superheater (Foster)	Power Specialty Co.
Superheat	125 deg. F.
Coal burned	West Virginia

STOKERS

Manufacturer	Combustion Engineering Corp.
Type	E
Number of retorts	One
Stoker drive	Direct steam cylinder
Arches	M. H. Detrick Co.

COAL BUNKER

Manufacturer	Stearns Conveyor Co.
Type	Suspended, steel
Capacity	500 tons

CHIMNEY

Builder	Weber Chimney Co.
Type	Reinforced concrete
Diameter, at top	12 ft.
Height above base	175 ft.

FORCED DRAFT FANS

Manufacturer	Clarage Fan Co.
Number installed	6
Type	Single-inlet, Hor. top discharge
Capacity, cu.ft. per min., 5 in. static press.	20,000
Drive, 7 x 7 in., 30-hp. vertical engine, belted.	Engberg's Electric and Mechanical Works
Regulators (individual)	Ruggles-Klingerman Co.

INDUCED DRAFT FANS

Manufacturer	Clarage Fan Co.
Number installed	6
Type	¾ housing, single-inlet, bottom discharge
Capacity, cu. ft. per min., 3½ in. static press.	32,000
Drive, 7 x 7 in., 30 hp. vert. engine,	Engberg's Elec. & Mech. Works
Regulators (individual, Craig)	A. W. Cash Co.

ECONOMIZERS

Manufacturer (Foster)	Power Specialty Co.
Number installed	6
Type	Armored tube, counterflow
Heating surface of each	1,710 sq.ft.
Economizer performance based on operating boilers at 150 per cent of rating:	
Gas per hr.	60,000 lb.
Water per hr.	22,500 lb.
Temperature of gas entering	550 deg. F.
Temperature of gas leaving	390 deg. F.
Drop in gas temp.	160 deg. F.
Temp. of water entering	200 deg. F.
Temp. of water leaving	313 deg. F.
Rise in water temp.	113 deg. F.
Drop in draft through economizer, in water	0.7 in.

FEED WATER PUMPS

Two single steam, 18 x 12 x 20 in.	Union Steam Pump Co.
One centrifugal, 200 g.p.m.	Union Steam Pump Co.
Drive, steam turbine 60 hp	Terry Steam Turbine Co.

MISCELLANEOUS EQUIPMENT

Coal handling equipment	Stephens-Adamson Mfg. Co.
Crusher single roll, 50 tons per hr.	Stephens-Adamson Mfg. Co.
Skip hoist, ashes	Stephens-Adamson Mfg. Co.
Industrial car	Stephens-Adamson Mfg. Co.
Ash scales	Fairbanks-Morse & Co.
Ash tank, hollow tile	Kalamazoo Tank & Silo Co.
Coal scales, automatic, six	Richardson Scale Co.
Feed water heater, open 120,000 lb. per hr.	Colles Heater Co.
Grease extractor	Blackburn-Smith Corp.
Water softener, cold process	Wm. B. Scaife & Sons Co.
Steam traps	Armstrong Machine Works
Steam separators	Crane Co.
Water columns	Williams Gauge Co.
Feed water regulators (Copes)	Northern Equipment Co.
Blowoff valves	Yarnall-Waring Co.
Non-return automatic stop and check valves,	Ford Regulator Corp.
Safety valves	Crane Co.
Misc. steam and water valves	Crane Co.
Piping	Wheeler-Blaney Co.
Piping covering, asbestos	Johns-Manville, Inc.
Firebrick	Taylor & Sons & Portsmouth Straight Brick
Steel runways	Kirlow Steel Floor Co.
Roof ventilators, six 48-in. (Swartwout)	Ohio Body & Blower Co.
Flowmeters, steam	Bailey Meter Co.
Draft gages (three-in-one)	Bailey Meter Co.
Recording thermometers	Foxboro Co.
Pressure gages (Am. st. gage and valve),	Schaeffer & Budenberg Mfg. Co.

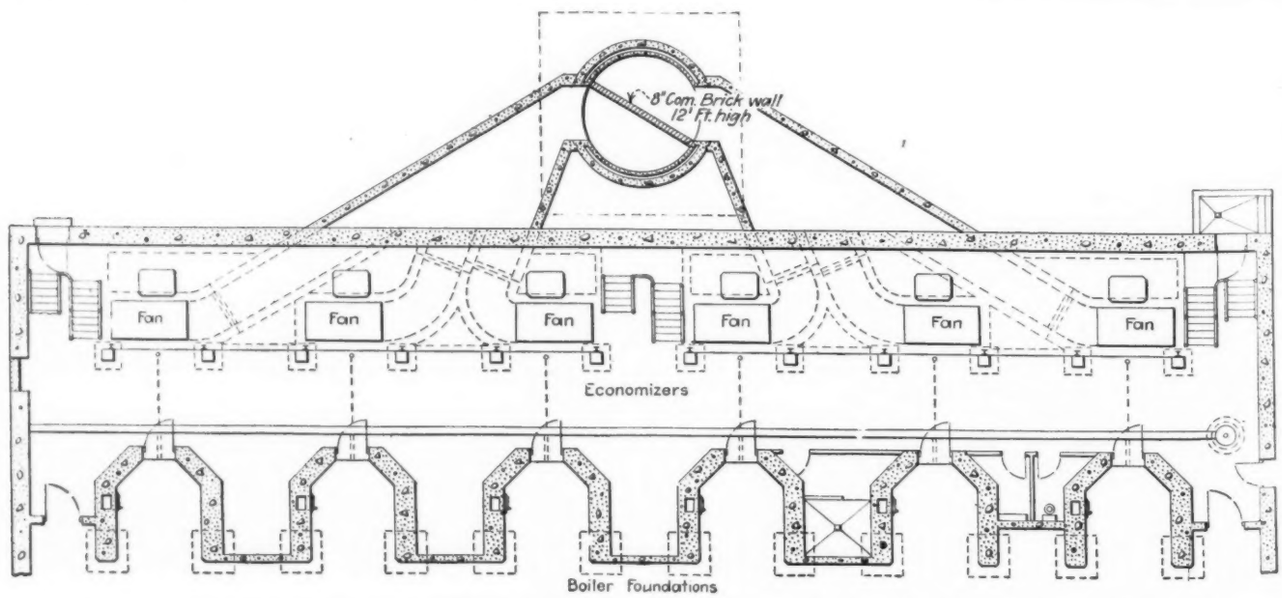
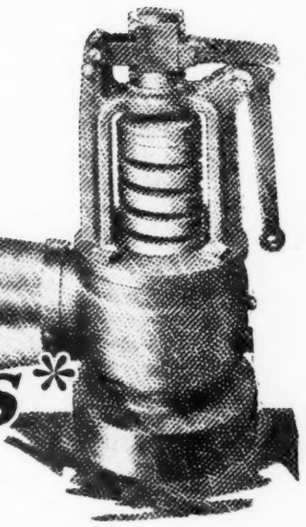


FIG. 12—PLAN OF BASEMENT, SHOWING BOILER FOUNDATIONS AND ARRANGEMENT OF SMOKE FLUES

The How and Why of Safety Valves*



Much has been written about boiler safety valves, and there have been endless discussions as to their theory and operation, but the engineering public, both practical and technical, remains for the most part uninformed on the fundamentals governing their design and use. This article aims to remove the mystery that surrounds the working of safety valves. Starting with an explanation of the underlying principles, it reaches conclusions of practical value to the operating engineer. Typical safety valves are shown and briefly described.

BEFORE taking up the practical features of pop safety valves, it is important to get a clear picture of the general principles that underlie the operation of the different types. For this purpose the diagrams, Figs. 1 and 2, are given, the first being a simple spring-loaded valve and the other a "pop" valve typical of the commercial safety valve.

In the simple spring-loaded valve shown in Fig. 1 the disk is held against the seat by the compression of the spring. The actual seat is a narrow strip assumed to be at the circle forming the inner edge of the bevel. The upward force on the disk will thus be the product of the area of this circle in square inches by the steam pressure in pounds per square inch gage. Theoretically, leakage will not begin until this force equals the downward force exerted by the spring, but no seat can be made so nearly perfect as to remain tight without some small downward force on the disk, so that actual leakage must start a pound or so below the pressure theoretically figured. The figure at the left shows the valve just before leakage starts, the pressure distribution over the face of the valve being shown beneath.

The diagram at the right shows the valve slightly lifted, forming an annular (ring-shaped) nozzle through which a small amount of steam discharges. Since the disk is now slightly higher than before, the downward force exerted by the spring, and hence the balancing upward push on the disk, must also be somewhat greater. The curve on the lower right shows how the pressure distribution has changed. The flow of steam produces a slight pressure drop in the throat, thus reducing the static pressure on the flat face of the disk, but this is more than balanced by the pressure of the escaping steam on the newly exposed area of the bevel, plus the slight impact on the lower face caused by the steam flowing up the throat. Such a valve cannot pop open. The sudden lift when leakage begins is too small to be of any importance, because of the small additional area exposed and the low average pressure acting upon it. Further lifting of the disk cannot occur unless the steam pressure is increased.

Valves Must Pop To Be Practicable

To avoid "simmering," wiredrawing and other defects of such a valve, practical safety valves must be designed to pop open. In order to accomplish this, it is necessary to provide for a sudden cumulative increase of lifting effort when an appreciable quantity of steam begins to leak past the seat.

This may be accomplished in several ways. One is to extend the disk and thereby form another and outer orifice so that the steam is partly confined, or "huddled," to produce static pressure on the newly exposed area. Another is to allow the escaping steam to impinge on a portion of the disk in such a way that the impact of the jet produces an additional lifting effect. Again, the jet may be deflected downward by projections on the disk, thus producing an upward reaction. Most valves employ all three of these principles to a greater or less extent.

The two halves of Fig. 2 show such a valve and seat before and after the pop. At the left is the valve just before steam begins to leak past the seat, which is assumed to be at the inner edge of the bevel. A slight increase in pressure starts leakage and a slight further increase permits enough steam to act on the outer area of the disk to force it up suddenly a considerable distance, giving a large area for steam discharge. The additional lifting effect is due to the three causes already named—to static pressure produced by "huddling" or partly confining the steam under the outer area of the disk, to the impact of the jet upon the outer part of the disk and to the reaction of the jet forced downward again by the outer lip. The static

*This article was prepared in co-operation with R. J. S. Pigott, mechanical engineer, and G. S. Coffin, assistant mechanical engineer, both with Stevens & Wood, Inc., Consulting Engineers.

pressure on the outer portion of the disk can be increased by raising the adjusting ring, which in turn further restricts the passage of steam downward from the huddling chamber.

In the case shown the additional static pressure on the outer area is not sufficient to make up for the decrease in static pressure on the inner part of the disk. But when the impact is added, the total upward force is considerably higher than just before the valve started to lift.

It is obvious that the net force holding the disk against the seat immediately before opening is extremely small. For instance, the force holding a 3-in. valve disk against the seat at 2 lb. below the opening point is only 14 lb., with perhaps a steam pressure of 200 or more pounds per square inch under the disk. Considering the loading on the disk of a 3-in. gate valve, or the pressure exerted to make a globe valve of the same size tight under the same conditions, it is surprising that a safety valve is tight within 50 lb. of the opening point.

Some Leakage Unavoidable

Because of this reduction of the load on the seat as the popping point is approached, a safety valve, however carefully constructed, must start leaking at a pressure a little below the popping pressure. This leak gradually develops as the pressure increases and exerts more and more lifting effort, which in turn permits more steam to escape until a point is reached where the lifting effort "overbalances" the spring resistance. Thereupon the disk is suddenly forced upward until the total lifting effort is again balanced by the increased spring resistance. This constitutes the "pop." It may be accomplished in an instant with only a fraction of a pound increase in pressure or may

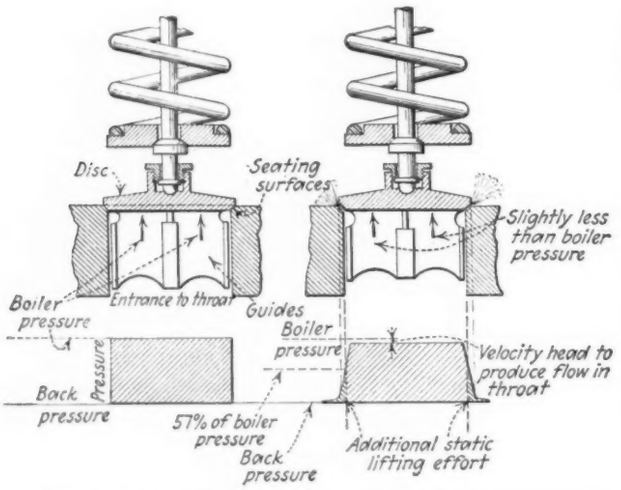


FIG. 1—DIAGRAM OF SIMPLE SPRING-LOADED VALVE.
Left: Just before steam starts to discharge. Right: Discharging a small amount of steam.

take several seconds or even minutes and a pressure increase of several pounds. Noiseless leakage is likely to occur several pounds below the popping point, but when the pressure approaches the popping point the leakage increases rapidly and hissing occurs. This is known as the "warning" and may continue for one or more pounds before the valve actually pops.

The height to which the disk is forced depends upon the spring design, the contour of seat and disk and upon the design and adjustment of the auxiliary devices causing the valve to pop. In any case the disk lifts with very slight accumulation of pressure to a height far exceeding that obtained with a simple valve, and maintains this lift as long as the steam pressure remains at the popping point. The lift varies with different sizes and designs from $\frac{1}{60}$ to $\frac{1}{4}$ of the diameter of the seat. As a lift of $\frac{1}{4}$ of the diameter is required

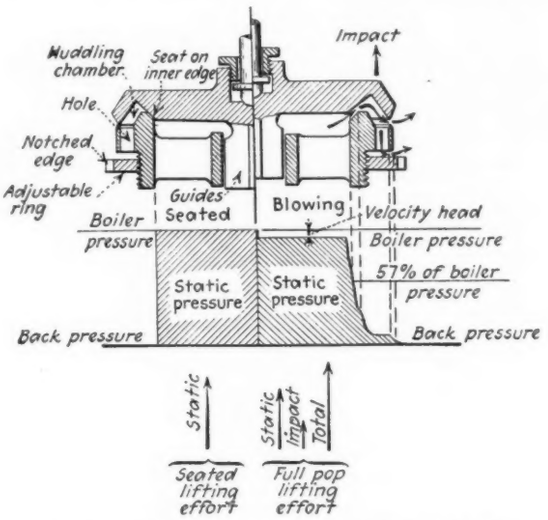


FIG. 2—DIAGRAM OF POP SAFETY VALVE
Left half: Just before steam starts to discharge. Right half: After the pop.

to discharge the full capacity of the throat, it is obvious that the diameter of the seat is not a reliable indication of the capacity of the valve.

To sum up, the spring-loaded pop valve has: First, a definite positive opening at a predetermined pressure; second, excess lifting effort to overcome the increased resistance of the spring and any reasonable friction; third, the ability to maintain a definite lift and steam discharge as long as the popping pressure is maintained in the boiler. This means that with a satisfactory safety valve the engineer can feel sure that when the steam pressure reaches a certain point the valve will open and discharge steam at a constant rate. If the valve discharge exceeds the rate of steaming, the pressure will be reduced and the valve will eventually close. If the rate of steaming exceeds the valve discharge, the steam pressure in the boiler will increase and the disk may rise slightly higher and discharge more steam. The valve or valves must be considered unsatisfactory if the pressure is allowed to increase more than 6 per cent over the set pressure, according to the A.S.M.E. Boiler Code.

Relation Between Pop and Blowdown

The safety valve that pops must have a "blowdown." After the valve pops open the disk will not reseat until the pressure is reduced well below the popping pressure. The fact that the valve can be held open by maintaining the steam pressure at the popping point means that the total lifting effort of the steam under these conditions equals the spring reaction at this lift of the disk. To bring the disk to its seat requires that this lifting effort be reduced. This is accomplished by reducing the static pressure under the disk and the quantity of steam being discharged. The dropping of the pressure will of itself reduce the quantity of steam

being discharged, but as the lifting effort is reduced also, the disk settles down and further reduces the flow. This action continues until the lifting effort cannot balance the spring load and the disk is suddenly forced to its seat by the spring. The operation is in some ways the reverse of popping, and the pressure reduction required to prevent reseating likewise depends upon the seat and disk contour and the characteristics of the spring and the auxiliary popping devices.

The A.S.M.E. Code limitations are 4 lb. blowdown when the boiler pressure is below 100 lb., 6 lb. between 100 and 200 lb. and 8 lb. above 200 lb. boiler pressure.

The control of blowdown is the most difficult feature of safety-valve design. The construction causing the pop also tends to hold the valve open and prolong the blowdown. Most valves have means for adjusting the blowdown, and it is very desirable that this adjustment be made on the boiler which the valve is to serve. Setting the blowdown, however, should be done very cautiously as it affects the popping lift and therefore the discharge capacity. In general, the longer the blowdown, the greater is the lift and discharge capacity. Furthermore, a reasonable blowdown serves a useful purpose in that it causes a reduction in pressure and permits the fireman to regulate the fire in time to prevent the valve popping again. A very short blowdown usually means frequent operation of the valve with resulting wear. Moreover, a proper blowdown causes the valve disk to be forced to its seat with enough pressure to produce intimate contact and consequently a tight seat. With a very short blowdown the closing force is small so that any slight friction of the moving parts or small particles on the seat will prevent the valve from closing tightly.

It is particularly important that the blowdown point be definitely known if the boiler pressure is close to the set pressure at any condition of operation. If, when running at high rating, the boiler operating pressure exceeds the blowdown point, the valve, having once popped will never have an opportunity to close again unless the pressure is reduced to normal. This is equally true if the valve has a tendency to warn. Should the pressure increase into the warning region and still not cause the valves to pop, it may be impossible to make it close tightly even when the pressure is reduced to the blowdown point. The positive closing that insures a tight seat under normal blowdown conditions is absent and the valve operates as a simple spring-loaded valve without pop or blowdown. It is therefore likely to simmer, with consequent cutting of the seat.

Changing of the set pressure is often necessary, sometimes because of the spring taking a "set," but more often because of error in the boiler gage or else a change in operating conditions. A reliable safety valve, if once properly adjusted, is a more accurate pressure indicator than the average gage. The changing of the pressure with the same spring also alters the blowdown, and both may affect the lift. Care should be taken that the spring and blowdown limitations are not reached and (even should the blowdown be satisfactory) that the lift is not reduced below that required for safety.

A valve may flutter considerably at popping, the action being similar to that of a kettle lid, and may continue to vibrate more or less noisily without doing any great damage other than unnecessary wear. This is often due to a wide seat or loosely fitting parts and is maintained through acoustic action (vibration like that of air in an organ pipe) in the valve chamber and connecting piping. Unsupported piping is likely to cause or assist in maintaining this action.

Chattering and hammering occur when the valve disk repeatedly strikes the seat and rebounds. The action may be mild, but is often extremely violent, sufficiently so to cause rapid destruction of the seat and disk and reduction in discharge capacity. This action is largely a matter of installation and blowdown. If the flow of steam to the valve is restricted in any way, the popping of the valve will cause a reduction of pressure which,

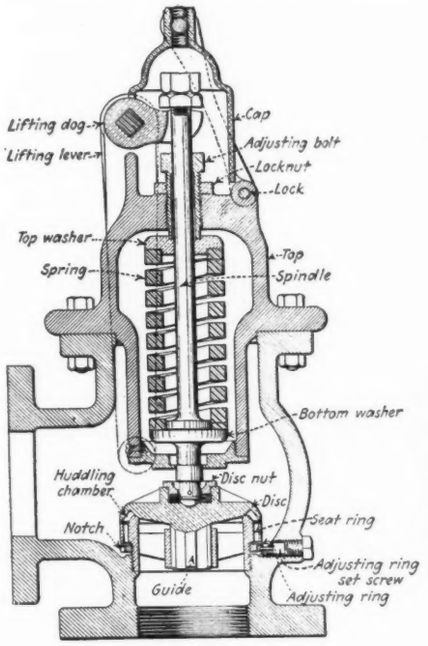


FIG. 3—CROSBY VALVE.

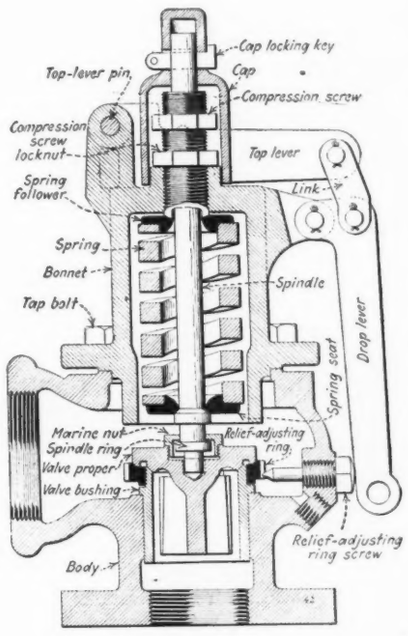


FIG. 4—AMERICAN VALVE.

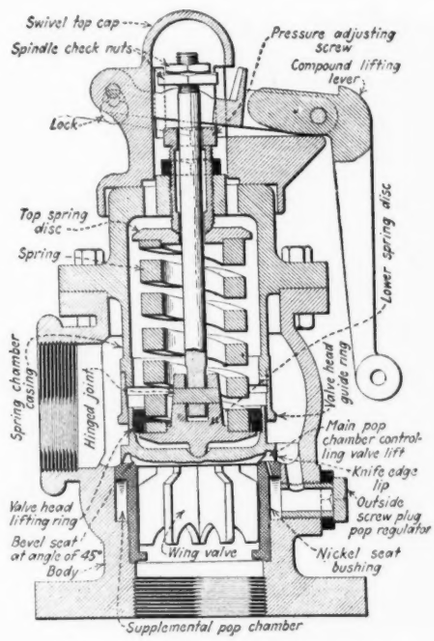


FIG. 5—ASHTON VALVE.

if sufficiently great, may immediately operate to close it. The stopping of the flow causes the pressure to build up again to the popping point so that the valve opens and the operation is repeated.

The restricted flow may be caused by an actual constriction in the inlet connection or may be due to poor entrance conditions, improper fittings or to the length and size of pipe between boiler and safety valve. The frictional resistance offered by a short length of pipe when the valve is discharging may be just sufficient to reduce the pressure to the blowdown point. In such a case a slight increase of blowdown may correct the trouble, but it is far better to install the valve directly on the boiler wherever possible, thus eliminating any unnecessary friction and providing as smooth a flow as possible from the steam space to the valve.

Perhaps the most troublesome feature of safety valves is leakage. The actual loss of steam is usually immaterial when other leaks such as occur at blowoff valves, stuffing boxes, traps, etc., are considered, but it is unsightly and the leak will often develop until seat cutting and erosion of vital surfaces occur.

Leakage may be due to normal causes such as have been previously mentioned. The operating pressure may be such that the valve is not permitted to reseat or the adjustment may be such that the valve warns at a pressure below the blowdown point. However, the valve may be actually leaking and from a number of different causes, of which the more important are as follows:

The valve may be held open slightly by some solid particle caught between the seat and disk at blowdown. This particle may remain or it may simply indent the seat and then be blown out. It must be remembered that the pressure between the seat and disk is very slight and that accurate machining is required, together with perfect alignment. It is therefore necessary to make the seat very narrow—much more so than is generally supposed. Even on large valves the actual seating contact rarely exceeds $\frac{1}{16}$ in. and is often considerably less. Breaking through this narrow ring is of course not difficult, and the slightest indentation will cause leakage. In this connection it is perhaps desirable to call attention to the usual method of making seats. The disk should have a slightly different angle from the seat and be so shaped that the circle of contact will be as small as possible. This insures a narrow seat and a minimum area of contact, which in turn gives the highest loading per unit of this area.

Finally, lack of alignment between the seat and disk may cause leaking. Poorly fitting guides or scale may lock the disk or hold it open. Binding of the spindle against the spring or adjusting bolt may operate to force the disk out of line.

Distortion of the seating surfaces of the valve is often sufficient to produce leakage. This may be caused by unequal expansion, or it may be due to distortion of the body from piping strains, such as frequently result from unsupported outlet piping.

Leakage may also occur between the seat ring and body (a condition often difficult to detect) or be due to poor castings. In testing safety valves for tightness, it must be remembered that a cold valve will often leak until it is thoroughly heated throughout, also that, if test conditions do not permit a proper blowdown or if the valve is partly opened by the lifting mechanism, it may not properly reseat until the pressure is reduced.

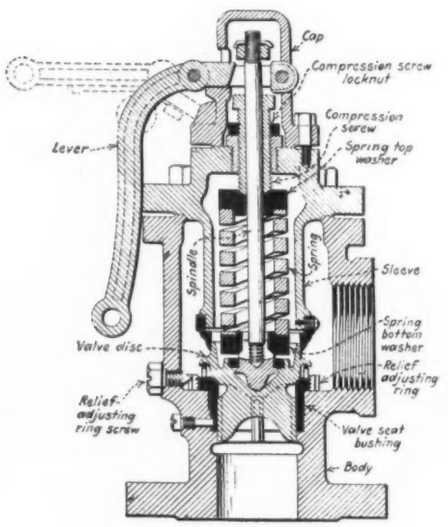


FIG. 6—LUNKENHEIMER VALVE

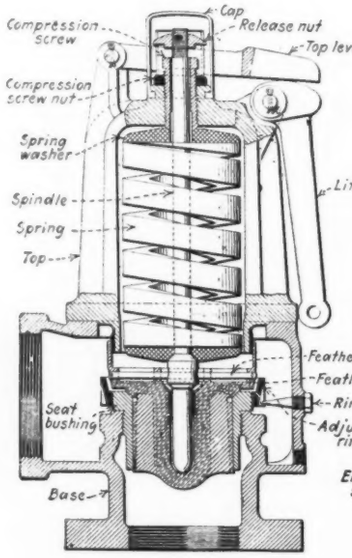


FIG. 7—CONSOLIDATED VALVE.

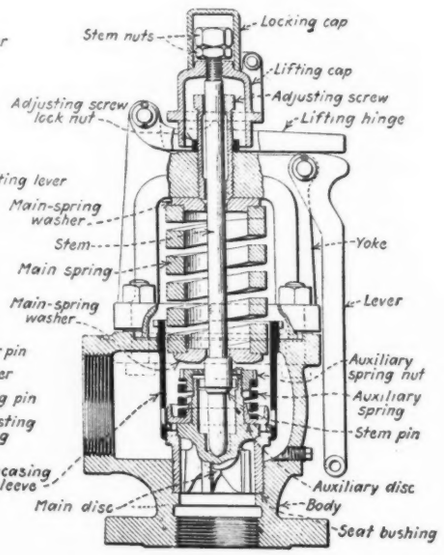


FIG. 8—CRANE VALVE.

Space limitations allow only a brief description of a few typical designs of pop safety valves as shown in Figs. 3 to 8. These were selected at random as good illustrations of the many styles of safety valves commonly used on stationary boilers. In most cases the manufacturers make other styles of safety valves in addition to those shown.

The Crosby valve shown in Fig. 3 uses a design of disk and huddling chamber similar to that already described in connection with Fig. 2. The popping pressure is increased by screwing down the spring-adjusting bolt to increase the spring compression, while the blowdown is increased by raising the adjusting ring to the desired point, after which it is locked in place with the setscrew.

Fig. 4 shows the American valve. This also has an adjusting ring, but the principle of operation differs from that of the valve just described. In the former the jet of steam thrown down by the outer lip of the

disk divides into two portions, part escaping from under the lip of the valve and the remainder passing downward through holes in the seat ring and then escaping through the annular space above the adjusting ring. In Fig. 4 all the steam discharges through the space between the adjusting ring and the outer lip of the disk. As before, raising the ring increases the static pressure in the huddling chamber, thus increasing the pop lift and the blowdown.

The Ashton valve shown in Fig. 5 eliminates the adjusting ring, using instead a special chamber whose outlet may be restricted as desired by means of an adjusting plug. Otherwise the action is similar to that explained in connection with Fig. 3.

Among the special features of the Lunkenheimer valve shown in Fig. 6 is the smoothly curved discharge lip of the disk. The amount of steam escaping from under the edge of this lip is controlled by a relief-adjusting ring which may be moved to cover any desired portion of the holes in the base of the huddling chamber.

Two valves of the outside-spring type are shown in Figs. 7 and 8. The huddling chamber of the Consolidated valve (Fig. 7) differs considerably from those of valves so far described. The steam passing the valve seat impinges on the flat outer ring of the disk and then passes upward through an annular orifice formed between the outer edge of the disk and the inner conical surface of the adjusting ring. On account of the conical shape of the surfaces, raising the ring restricts the discharge from the huddling chamber and increases the pop lift and the blowdown.

The Crane valve shown in Fig. 8 also differs from all previously described in that it makes use of an auxiliary spring and disk. A study of the drawing will make it clear that increasing the auxiliary spring compression restricts the upward flow of steam through openings in the outer edge of the main disk. This raises the combined static pressure on the two disks and thus increases the pop lift.

The Bureau of Mines is now engaged on an extensive investigation of explosions in tanks, cylinders, etc., containing compressed oxygen. So many factors are involved that the study promises to be unusually difficult.

Steam Consumption in Various Types of Buildings in Detroit*

The following questions are often asked of central-station heating companies:

1. How does the steam consumption in a building vary with the outside temperature?
2. How does the steam consumption vary with the type of building?
3. If we know the installed radiation in a building, how can we determine the steam consumption?
4. Am I using more or less steam than the average building of this type?

To answer these questions with some degree of intelligence, the curves shown herewith were prepared. The Detroit Edison Co. serves about 2,000 customers, 150 of whom have over 4,000 sq.ft. of equivalent direct radiation. These larger buildings were divided into sixteen typical classes. Meter readings were taken at intervals of from two to seven days on each building for the heating season 1921-22. The average outside temperature was obtained for each meter-reading interval. A curve was plotted for each building with temperature as the abscissa and steam consumption per day per square foot of radiation as the ordinate. The curves for the buildings of each type were averaged and plotted as shown in the illustrations.

With these it is possible to determine the temperature-steam consumption relation in any type of building. It will be noticed that in most cases there is almost a straight-line relation between the steam consumption and the outside temperature. The usual practice of correcting steam consumption to some other outside temperature by using the difference between some assumed inside temperature and the outside temperature is sufficiently correct for most purposes, if the outside temperature at which the steam consumption is zero, is considered as the inside temperature to be maintained. This temperature, as the curves indicate, is usually between 60 and 68 deg. Using 70 deg. F. as the inside temperature is not always correct because, when the

*From report of the Heat Utilization Committee of the National District Heating Association, submitted by J. E. Seiter, of the Detroit Edison Co.

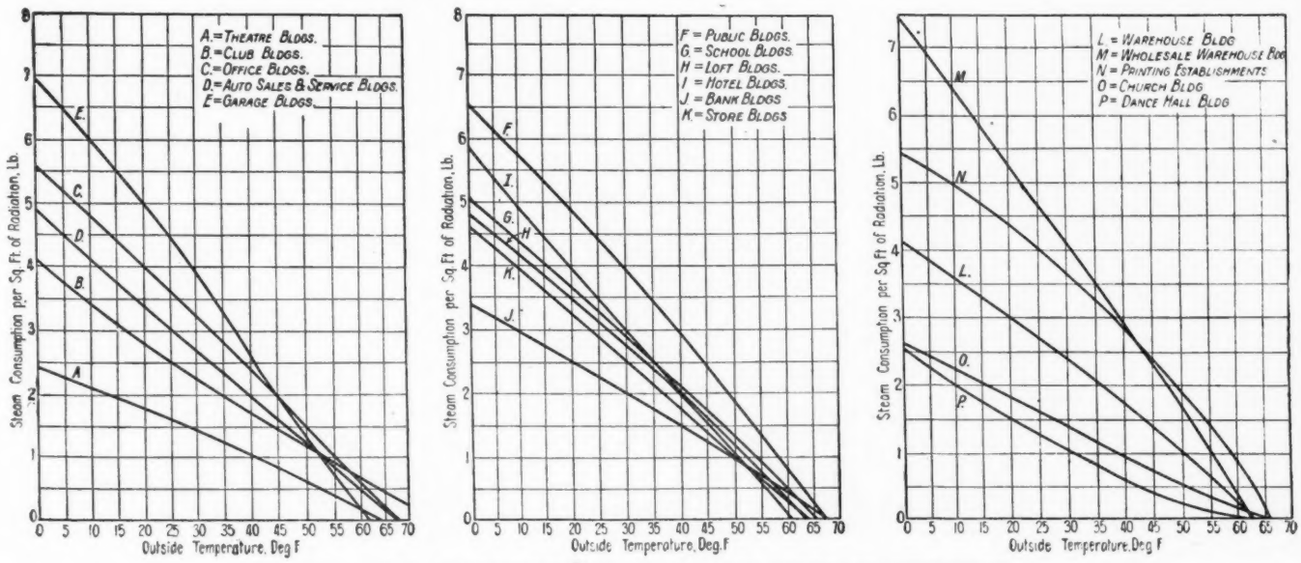


FIG. 1—STEAM CONSUMPTION OF VARIOUS TYPES OF BUILDINGS

average outside temperature is between 60 and 68 deg. F., the actual temperature during the day when steam is used is above 70 deg. F. and theoretically no heat is required.

It will be noticed that the steam consumption per square foot of radiation varies greatly for different types of building. Tnis is as would be expected and emphasizes the fact that average figures for an entire central heating system cannot be used in making estimates with any degree of accuracy.

To determine the steam consumption for any type of building, knowing the average temperature for a

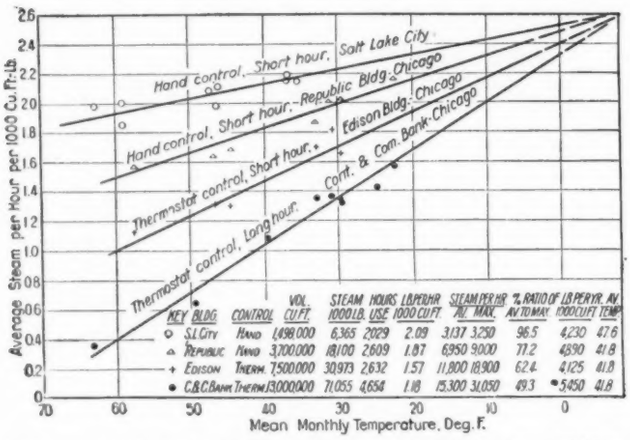

Hand control, Short hour, Salt Lake City
Hand control, Short hour, Republic Bldg, Chicago
Thermostat control, Short hour, Edison Bldg, Chicago
Thermostat control, Long hour, Cont. & Com. Bank, Chicago
Average Steam per Hour per 1000 Cu. Ft. Bldg.
Mean Monthly Temperature, Deg. F.
KEY BLDG CONTROL VOL. CU FT. STEAM 1000 LB. HOURS USE LB/PER/HR 1000 CU FT. STEAM PER HR AV. MAX. % RATIO OF LB/PER/HR AV TO MAX. LB/PER/YR. AV 1000 CU FT TEMP
S.L City Hand 1,498,000 6,365 2029 2.09 3,137 3,250 96.5 4,230 47.6
Republic Hand 3,700,000 18,100 2609 1.87 6,950 9,000 77.2 4,890 41.8
Edison Therm. 7,500,000 30,973 2632 1.57 11,800 18,900 62.4 4,125 41.8
C.B.C.Bank Therm. 13,000,000 71,055 4,654 1.18 15,300 31,050 49.3 *5,450 41.8

FIG. 2—HAND VS. THERMOSTATIC CONTROL AND SHORT-HOUR VS. LONG-HOUR HEATING

heating season, multiply the steam consumption per day per square foot of radiation corresponding to the type of building for this temperature, by the radiation and the number of days in the heating season. This method is approximately correct for buildings whose curves are nearly straight lines; for other types of buildings the consumptions will have to be integrated.

These curves are valuable in comparing the steam consumption of an individual building with the average for its type. They will serve as a criterion of the degree of economy practical in the operation of the heating system of the building.

In case the building is not properly equipped with radiation, the curves will not apply. In such cases the theoretical required radiation should be used.

In the discussion of this committee report the chart shown in Fig. 2 was presented to show the difference in steam consumption between hand control and thermostatic control and the difference between short-hour and long-hour heating. Data on four different buildings had been obtained, as indicated on the chart, and the steam consumption plotted against the mean monthly temperature.

It will be noticed that thermostatic control has a decided advantage over hand control. In the curves, long-hour heating has the advantage of short-hour heating, considering hourly consumption, but when the steam consumption over the period of a year is taken, the short-hour heating shows a decided saving. Reference to the tabular matter on the chart illustrates this point.

It is almost universal practice in this country to rate stationary boilers to evaporate 3.45 lb. of water per hour "from and at 212 deg." per square foot of heating surface. This requires $3.45 \times 970.4 = 3{,}348$ B.t.u.

The Pender Draft Gage Firing Indicator

The draft gage is capable of indicating correct pressure of the air supply or furnace gas necessary to maintain test conditions on the boiler, which for everyday operation should be standard conditions in order to operate the boiler and furnace at the highest efficiency.

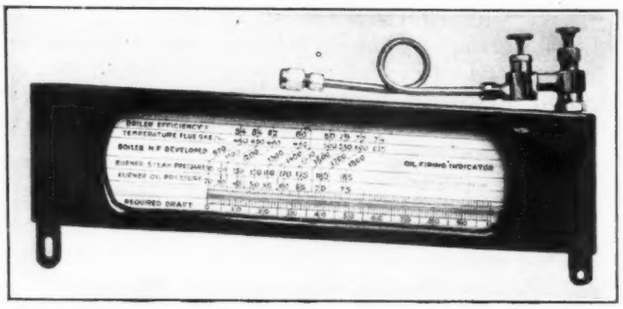
In developing the firing indicator shown herewith, the object was to combine the boiler-test data with the draft-gage scale in a form that would be of service to the fireman. As the draft gage is one of the most common and important instruments required to maintain economical operating conditions of the boiler and furnace, a great amount of information has been developed, but seldom placed in a form of service to the fireman.

The instrument here shown is equipped with standard fittings and an enlarged case to accommodate the scale, which has space for all necessary data.

As each boiler will have individual operating characteristics, the scale is sent blank, and the test data may be filled in for each boiler rating desired.

The boiler test determines the best possible operating conditions and the controlling factors, which for any fuel would be the lowest draft at the damper or draft drop through the boiler and the lowest flue-gas temperature, with the boiler surface clean externally and internally. These factors are determined for each boiler rating at which the boiler will be operated.

Referring to the illustration of the completed scale, which was made for an oil-fired and steam-atomized oil furnace, the required oil and steam pressures on the burners are filled in on the scale, with their relation to the other controlling factors. For any other fuel the relation could be shown with their respective units. For mechanical oil atomizing, the air pressure at the register can be shown over the oil pressure. In burning fuel oil it is well known that the temperature has an effect on the quantity of fuel oil delivered with a given pressure, also the oil will atomize more efficiently at a certain temperature; for this reason a temperature

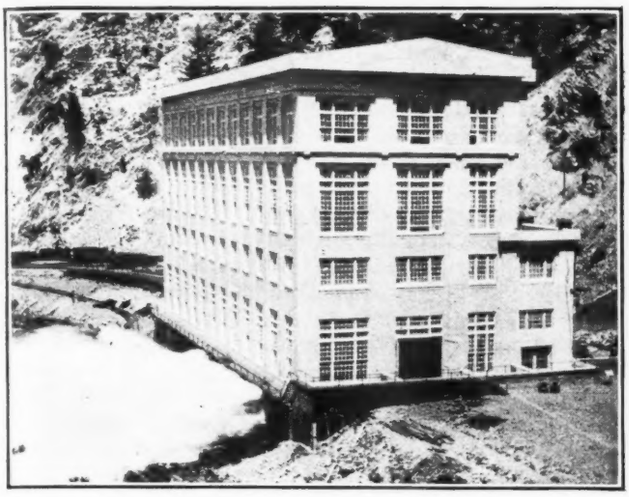


FIGURES PLACED ON DRAFT GAGE SCALE SERVE AS A GUIDE FOR FIREMAN

should be established and maintained to insure a certain quantity at a given pressure.

For gas-fired furnaces the gas pressure can be placed over the scale. For coal-fired furnaces the rate of coal per minute or hour, or rate of stoker travel can be filled in on the scale. For any kind of fuel the flue-gas temperature will have a given relation to the boiler rating and draft drop. These three factors, when obtained with the boiler operated and maintained at the highest economy, will serve as a standard and a guide for the fireman in the daily operation of the boiler.

This instrument is manufactured by the Jos. W. Hays Corporation, Michigan City, Indiana.



The Operation of Hydro-Electric Stations

By RALPH BROWN*

TWO conditions under which hydro-electric plants are operated to obtain the greatest output are where there is a limited amount of water and where there is an excess of water.

IN THE operation of hydro-electric plants there are two conditions which it is advisable to strive for—economical output in one case and maximum output in the other, both of which are measured by kilowatt-hours. The first condition exists when the stream flow is deficient, that is, less than the quantity required to produce from a given installation the power for which there is a market; the second condition exists when the stream flow is ample for maximum output operation and there is a demand for every kilowatt-hour that may be generated.

Economical-output operation should be followed during those more or less seasonal periods when the stream flow is deficient, for it is then essential that every effort be directed toward the delivery of the maximum amount of energy with the minimum consumption of water. During those periods when the stream flow is as great as, or in excess of, the amount of water that may be discharged through the turbines, maximum-output operation is called for, because it is then necessary to deliver the maximum number of kilowatt-hours, regardless of the amount of water used.

In this article matters relating to the design and selection of station equipment will not be alluded to, for after a station is placed in operation it is generally of little avail to consider what might have been done to obtain better operating characteristics or higher efficiencies, the problem being to obtain the maximum output from the equipment available. And if it can be demonstrated that it will prove profitable to remodel or replace certain equipment, an experienced designer is obviously better qualified to deal with the problem than one concerned mostly with station operation.

Such equipment as hydraulic turbines, generators and transformers are usually sold under quite rigid guarantees as to efficiency. Although efficiency tests may be conducted after installation, transformers and generators operate under conditions that can be closely approximated on the test floor, hence the efficiency figures supplied by the manufacturers of such equipment can deviate but little from those obtaining during actual operation.

Conditions, however, are somewhat different in the case of turbines, for while small models of such equipment can be, and usually are, tested in the builder's laboratory or at a testing station, it is obviously a physical impossibility to test even a small turbine in the shop. Of course a builder can closely calculate, from the results of tests conducted on a small homologous runner, the efficiencies to be expected from a large turbine, but these efficiency figures can be confirmed only by a test made after the machine is installed.

If a turbine discharges a large amount of water, as in a low-head plant, and no provision is made at the time the station is constructed for measuring this water, it will be difficult and probably expensive to conduct satisfactory tests. In such cases, where the expense of conducting efficiency tests would certainly seem to be justified, about the best that can be done is to accept the results of tests applying to model homologous

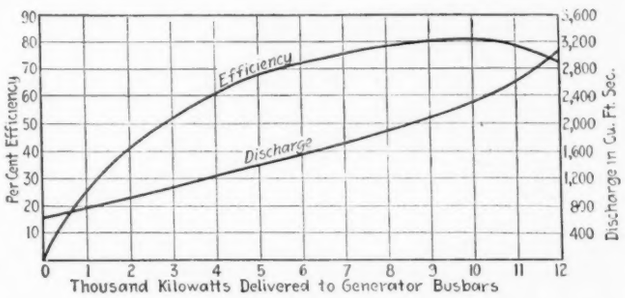


FIG. 1—EFFICIENCY DISCHARGE CURVES FOR LOW-HEAD REACTION TURBINE GENERATING UNIT

runners. Within the last three or four years there have been developed two methods of water measurement in closed penstocks of suitable length that make it comparatively simple and inexpensive to run efficiency tests on hydro-electric units of any capacity without interfering with normal operation. It is the opinion of the writer that the expense of conducting efficiency tests is warranted in every plant where economical operation is justified or where exact knowledge of the performance of generating equipment is desired.

Fig. 1 shows an efficiency-discharge curve of a low-head turbine-generator unit, operating under a constant head and speed, and for convenience all the losses, from the forebay to the generator bus, are included. It will be noted that the maximum over-all efficiency is 81 per cent, and while this is an efficient machine, over-all efficiencies as high as 91 per cent have been obtained from large modern medium-head units.

As the load is increased on a reaction turbine, the head will generally decrease, because, even if the ele-

*The Great Western Power Company.

vation of the forebay remains unchanged, the elevation of the tailrace will usually increase. The setting of impulse turbines is such that no reduction of head occurs due to increased tailrace elevation at maximum load; and regardless of the head, the speed or frequency must remain constant. Maximum efficiency should be

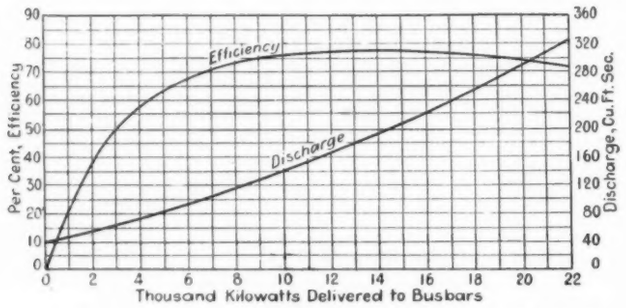


FIG. 2—EFFICIENCY DISCHARGE CURVES FOR HIGH-HEAD IMPULSE TURBINE GENERATING UNIT

obtained when a turbine operates under the head and at the speed for which it was designed, and while the output increases as the head is increased, the speed remaining constant, therefore a reduction in the over-all efficiency results in a properly designed machine. However, the increased output resulting from an increase in head, despite the decreased efficiency under which it is obtained, makes it profitable to operate a turbine under the highest possible head, flashboards being utilized for this purpose as well as for increasing pondage. For example, a certain generator, driven by a turbine under rated head, 62 ft., will deliver 3.97 kw. to the bus bars per cu.-ft.-sec. of water discharged, indicating an over-all efficiency of 75.3 per cent. If the head is increased to 65 ft., the same amount of water will make available 4.07 kw. at the bus bars, yet the efficiency has been reduced to 73.6 per cent.

Fig. 2 shows the calculated over-all efficiency, the penstock losses being included, of a large double-overhung impulse-turbine generating unit. The efficiency curve for a unit of this type is generally flatter and reaches the point of maximum efficiency at a lower percentage of full load than does a similar curve applying to a reaction-turbine generating unit. About the highest efficiency that will be obtained from an impulse turbine under commercial operating conditions is 86 per cent, but efficiencies as high as 91 per cent have been obtained from well-designed reaction turbines with draft tubes of the most efficient type.

Besides the inherently lower efficiency of an impulse turbine except when lightly loaded, the penstock losses are generally greater than similar losses to be expected where reaction turbines are employed, for impulse turbines generally operate under higher heads, usually requiring longer penstocks, than turbines of the reaction type. The efficiencies of long steel penstocks or pipe lines at full load lie usually between the limits of 90 and 96 per cent.

Referring to Fig. 2, it will be noted that the point of maximum over-all efficiency corresponds to a load of approximately 14,000 kw., and the efficiency is not less than 75 per cent for any load between the limits of 9,000 and 19,000 kw. While it would be advisable to maintain the load on this unit constant at 14,000 kw. to obtain the highest efficiency, any load between 12,000 and 16,000 kw., equally divided between both wheels, would be an economical one. If the load was 5,000 kw., the efficiency would be reduced to 63 per cent, and by the simple expedient of tightly closing one needle nozzle, thereby transferring the entire load to one runner, the efficiency would be increased to about 75 per cent, for with an output of 5,000 kw. from one runner the efficiency of the unit would correspond to nearly that of 10,000 kw. on two runners. For this particular double-overhung unit the highest efficiency will be obtained by using one nozzle only for all loads from 0 to 9,000 kilowatts.

Referring to Fig. 1, it will be noted that the efficiency of this unit is within the limits of 79 to 81 per cent for loads between 8,000 and 11,000 kw., hence if economical output operation were required the load should be maintained between these limits, preferably at 10,000 kw., the point of highest efficiency. Assuming that the load on the unit is 9,000 kw. and the head 63

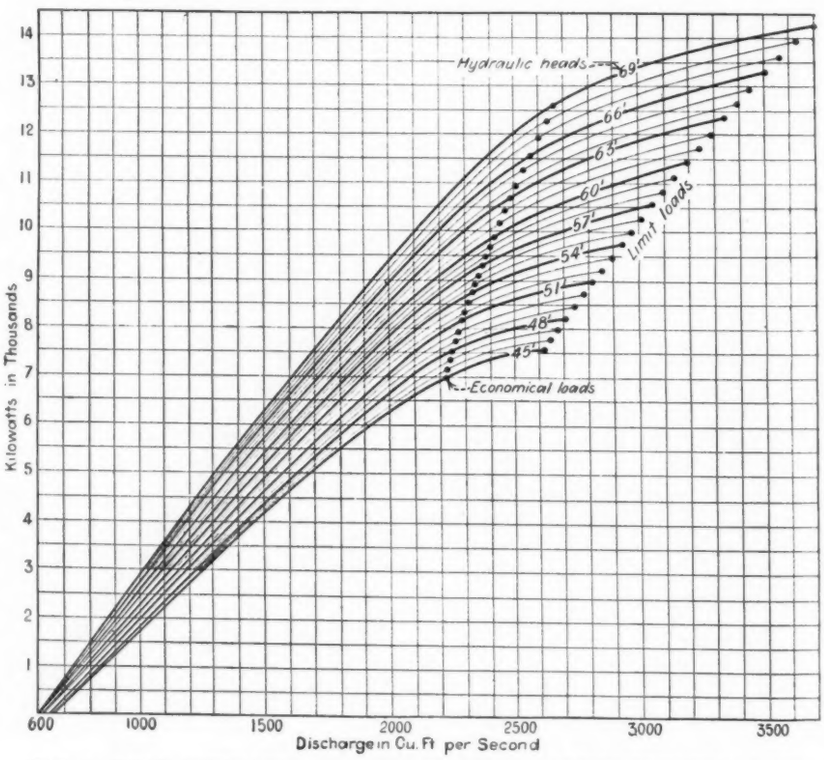


FIG. 3—LOAD DISCHARGE CURVES FOR LARGE HYDRO-ELECTRIC UNIT

ft., the turbine discharge at 100 per cent efficiency would be $\frac{0.085 \times 63}{9{,}000} = 1{,}681$ cu.-ft.-sec., but since the actual over-all efficiency is 80 per cent, the discharge is $\frac{0.085 \times 63 \times 0.80}{9{,}000} = 2{,}101$ cu.-ft.-sec., and the number of kilowatts per second-foot, or kilowatt equivalent,

is $\frac{9,000}{2,101} = 4.28$. If four such units were generating 9,000 kw. each under a head of 63 ft. the total discharge, or draft, would be 8,400 cu.-ft.-sec., and if this load of 36,000 kw. were equally divided among six units, the discharge per unit would be 1,550 cu.-ft.-sec., corresponding to a draft of 9,300 cu.-ft.-sec. Hence, a saving of 900 cu.-ft.-sec. results if 36,000 kw. is generated on four instead of six units. This amount of water, if utilized at an efficiency of 75 per cent under a head of 63 ft., would generate approximately 3,600 kw.-hr. per hour, which, at 3 mills per kilowatt-hour, would mean an hourly income of $10.80. Or, if the amount of power wasted by generating 36,000 kw. on six instead of four units had to be produced by steam generation, about five tons of coal or 1,000 gal. of crude oil would be consumed hourly. If the load per unit were reduced to 3,000 or 4,000 kw., the efficiency would be low, with a consequent increase in water consumption and probable reduction in head, due to the increase in the tailrace elevation because of the greater amount of water discharged.

On systems where deficient stream flow is compensated for by steam generation, more or less attention is directed toward economical hydro-electric generation, yet during protracted periods of low flow from 5 to 10 per cent in fuel cost might be saved in many cases if a special study of economical output operation was made, the most efficient methods consistently followed, and complete records of operation analyzed daily. In every hydro-electric plant some simple method should be

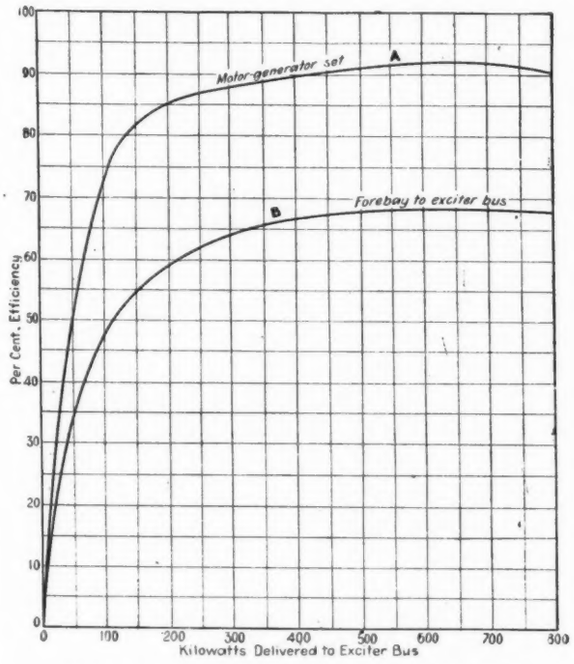


FIG. 4—MOTOR-GENERATOR EXCITER SET EFFICIENCY CURVES

available for determining, within commercial limits, the discharge, or draft through the turbines, and it is necessary that this quantity be made quickly available by a simple calculation or reference to curves or tables, in a plant where economical operation is to be followed.

In some plants, where venturi tubes are installed, the turbine discharge can be read directly, in others the draft can be obtained from a weir or a gaging station placed at a suitable location in the tailrace channel but the most common and often the only practicable method is to utilize the turbines themselves as water meters.

If the over-all efficiency of a generating unit, under the heads at which it is required to operate is known, preferably from tests in place, or can be calculated closely, a discharge-power curve may be plotted and the

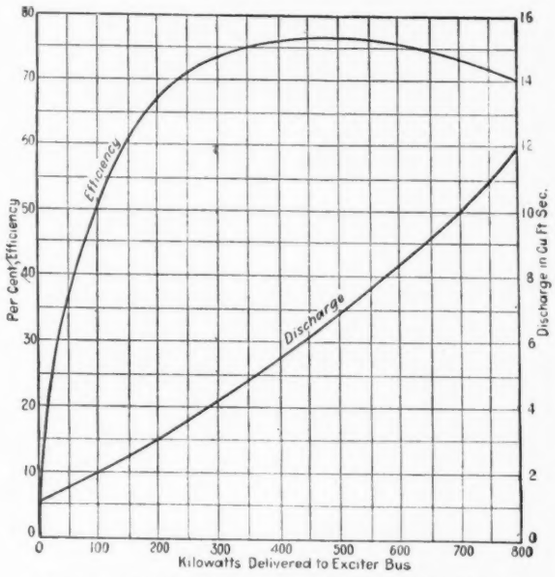


FIG. 5—REACTION-TURBINE DRIVEN EXCITER EFFICIENCY AND DISCHARGE CURVES

turbine discharge corresponding to the generator output, and the head, obtained therefrom. Since in low-head plants the head may vary 20 per cent or more within a period of 24 hours, it is evident that a discharge-power curve based on one head only would be of little practical value, hence a number of such curves should be plotted for each unit having different characteristics, for each value of head of approximately 2 per cent of rated head between the maximum and minimum heads met with in practice, as in Fig. 3. The point of most economical load on each curve should be shown by a small circle, likewise the point of maximum load. These curves should be plotted to a scale sufficiently large to permit of accurately reading the turbine discharge to within 0.5 per cent, and should be made in the form of a photostat or blueprint and kept beneath celluloid or glass at the switchboard for convenient reference of the operators. Tables indicating the most economical number of units to operate for any possible load and head should also be placed at the switchboard.

Where a record of turbine discharge is desired, it should be computed hourly from the discharge-power curves, thereby obtaining the cu-ft.-sec. per hour, by using as the output the hourly difference obtained from the generator watt-hour meter, the head being taken as the average of the heads at the beginning and end of the corresponding hour. The head on a reaction turbine is taken as the difference between the forebay and tailrace elevations, while for an impulse turbine the head is the difference between the forebay and nozzle elevations.

Forebay and tailrace elevations are usually obtained from staff gages, and such gages should be kept clean, frequently painted, and be well illuminated to facilitate reading. Electrically operated water-stage registers

are employed in some stations, but despite the advantage of recording elevations at the switchboard, the cost of maintaining some types of registers has discouraged their widespread use.

Although the energy required for excitation purposes rarely exceeds 1.5 per cent of the sum of the generator outputs, it will usually prove profitable to operate the units forming part of a central excitation system with strict regard to water economy during periods of economical-output operation. Where the excitation energy is generated by individual motor-generator sets or by exciters directly connected to the main units, relatively little can be done to decrease the amount of power required for excitation purposes, but where waterwheel-driven exciters are employed a saving may be effected.

Curve *A*, Fig. 4 shows the calculated efficiency of a motor-generator set used for excitation purposes, and curve *B* indicates the efficiency of the same set when all the losses from the forebay to the exciter bus are included, and is based on the assumption that energy is delivered to the main generator busbars at an over-all efficiency of 74 per cent. The curves shown in Fig. 5 indicate the efficiency of a waterwheel-driven exciter

KILOWATT EQUIVALENTS PER CUBIC-FOOT-SECOND OF WATER

Average Head	Average Kilowatts	Kilowatt Equivalent
1,100	0-150	47
1,100	151-300	67
1,100	301-600	70
1,100	601-800	68

set having the same rating as the motor-generator set. It will be noted that for outputs of less than 100 kw. there is little difference between the motor-generator set, considering all losses from the forebay to the excitation bus, and the waterwheel-driven set in regard to efficiency, while for outputs greater than 100 kw. the efficiency of the waterwheel set is decidedly better. Since in a large station there would probably be but two or three exciter units, it is not always possible to distribute the excitation load so that a high efficiency will be obtained from each unit.

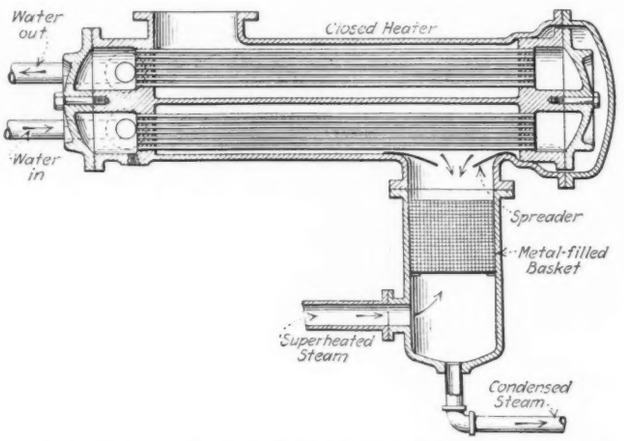
The discharge through the exciter turbines may be computed with sufficient accuracy by dividing the average output of each exciter for the day by the kilowatt equivalent corresponding to both this average and the average head. Assuming an average load of 250 kw. on No. 1 exciter and 350 kw. on No. 2 exciter, at an average head of 1,100 ft., the discharge from the kilowatt equivalents given in the table for exciter No. 1 will be $\frac{250}{67} = 3.7$ cu.-ft.-sec., and for exciter No. 2, $\frac{350}{70} = 5$ cu.-ft.-sec., giving a total average hourly discharge of 9 cu.-ft.-sec., which should be added to the draft through the main units to obtain the total station draft. Instead of using a table, the discharge may be obtained directly from a discharge-power curve, and if exciter watt-hour meters are not installed, the average exciter output will be the product of the average volts and amperes.

In all considerations pertaining to the economical or maximum-output operation of hydro-electric stations care must be taken to avoid any method of operation that may interfere with the rendering of continuous, reliable service, hence it would not ordinarily be advisable to take advantage of the saving that might result if only a motor-driven exciter were operated, assuming that a storage battery was not in parallel with the excitation bus.

A Method of De-Superheating Steam

BY A. G. CHRISTIE

It has been frequently stated that it is not desirable to admit superheated steam into closed feed-water heaters on account of the reduction of capacity of such heaters due to the low rate of heat transfer with superheated steam. Some method should therefore be provided for removing the superheat from the steam

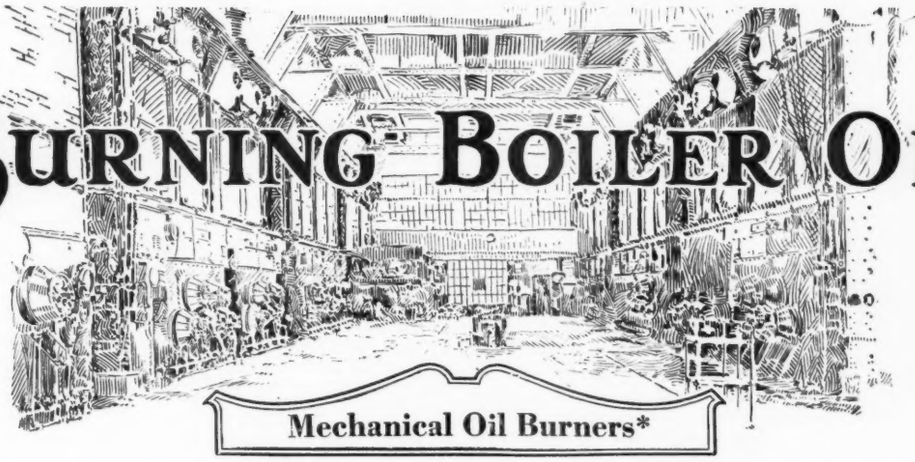


SUGGESTED ARRANGEMENT FOR DE-SUPERHEATING WITH CLOSED HEATER

before admitting it to the heater. Several forms of de-superheaters have appeared on the market, all of which involve the use of water from a separate source, either sprayed into the steam or allowed to cascade down over metal surfaces placed in the path of the superheated steam. The objection to these is that they involve additional piping, a clean water supply, extra cost and more auxiliaries that require maintenance and attention in operation.

A simpler method that has been suggested by the writer during past years is shown in the accompanying sketch. The closed heater, either of floating-head or hairpin type, is provided with a large deep hotwell in the upper portion of which is placed a wire-mesh basket containing any non-corrosive material that has large exposed surfaces and does not offer resistance to steam flow. Small sections of old condenser tubes, brass turnings or monel-metal strips might be used. The condensate from the heater tubes is spread over this basket by a deflector plate and drips down in thin streams over its contents. The superheated steam enters at the side of the hotwell below the basket and, in passing up through the metal contents of the basket, de-superheats itself by re-evaporating some of the descending condensate. The remainder of the condensate is drawn off from the bottom of the hotwell. Large exposed metal surfaces such as those in the basket have been found to serve effectively as de-superheaters.

The advantage of this scheme is that the steam de-superheats itself in a simple manner by means of its own condensate. No additional valves, piping, water supply or traps are needed for its operation. Finally, there are no working parts to get out of order and no maintenance or attention is required when in operation. Such an arrangement can be used advantageously on high-pressure bleeder heaters on large turbines, on gland steam heaters and with certain evaporators.



Burning Boiler Oil

Mechanical Oil Burners*

THE serious loss of boiler feed water experienced with steam-atomizing burners delayed for years the general use of boiler oil in the merchant marine. The necessity of some medium other than steam to act as the atomizing agent resulted in the design of air-blast burners and ultimately the development of the mechanical or pump-pressure atomizing burner. Even with a pump steam consumption equal to the atomizing steam consumption of the steam atomizer the mechanical type was to be preferred, since the pump exhaust steam was returned to the condenser. In addition the majority of older vessels had Scotch-type boilers whose cylindrical and relatively small diametrical furnaces were ill-adapted to a flat flame. It has been found that the mechanical atomizer is better adapted for boilers operating under wide load ranges. The individual burner does not have the capacity range possessed by a steam atomizer, but a number of mechanical burners may be placed in a single furnace, since

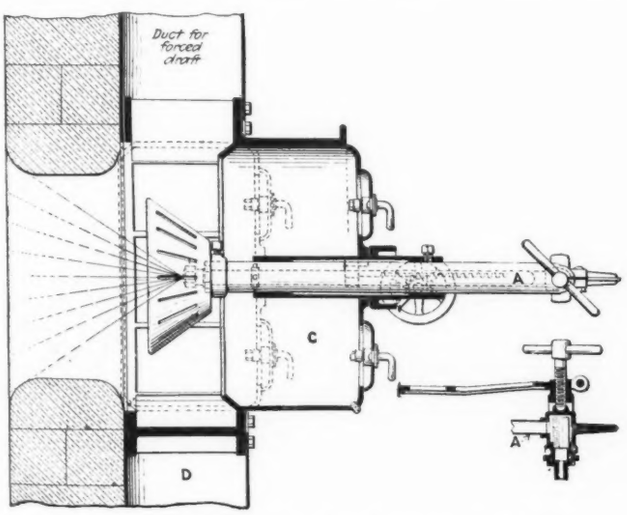


FIG. 1—BETHLEHEM MECHANICAL BURNER

the cone jet does not shut out the air from an adjacent burner, the air being introduced around each cone.

Another advantage claimed for the mechanical burner is the small furnace losses; for with the steam atomizer the heat in the steam at stack temperature is lost.

*This is the third article of this series; the others appeared in the issues of Aug. 7 and 21.

While the burner tip and atomizing chamber vary in design, in principle this class of burner consists of an oil tube having a tip in which the oil is given a whirling motion so that it issues out of the orifice in the

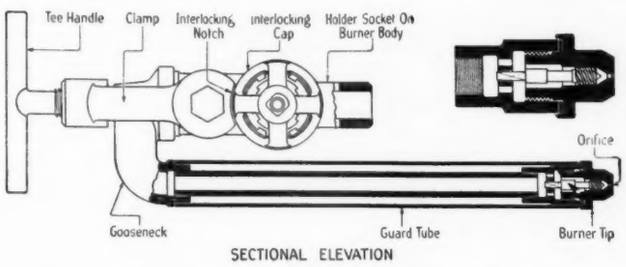


FIG. 2—SCHUTTE-KOERTING BURNER

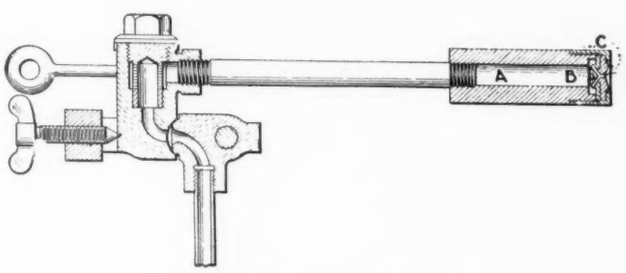


FIG. 3—TATE-JONES ATOMIZER

shape of a hollow cone. The burner is surrounded by an air register which allows the air to enter through adjustable vanes and mix with the oil spray after the oil has left the tip. The assembled burner and air register follows the general line of Fig. 1. Since the oil spray does not possess the induction effect of the steam-oil spray, unless the stack be fairly high the mechanical burner will require forced draft at all but low boiler ratings. A combination of natural and forced draft is often installed whereby forced draft may be used by closing the natural-draft passage and opening the gate leading to the forced-draft blower.

The type *D* burner of the Schutte & Koerting Co. is shown in Fig. 2. The oil passes through the center tube and at the burner tip is forced by the high pressure to pass around and along the helical screw. This gives a rotary motion to the oil, and when the jet leaves the tip it is in the form of a hollow cone, each particle of which has not only a forward but a circular motion as well. To eliminate trouble arising from dirt lodging

in the tip, a wire screen is placed in the oil line. A quick-detachable head is provided and a clamp and screw hold the burner head against the oil-line casting, allowing the burner to be removed for cleaning. As a safeguard against removing the burner while pressure is on the oil line, an interlocking device is incorporated in the design, whereby the clamp cannot be moved until the oil-line cock has been closed.

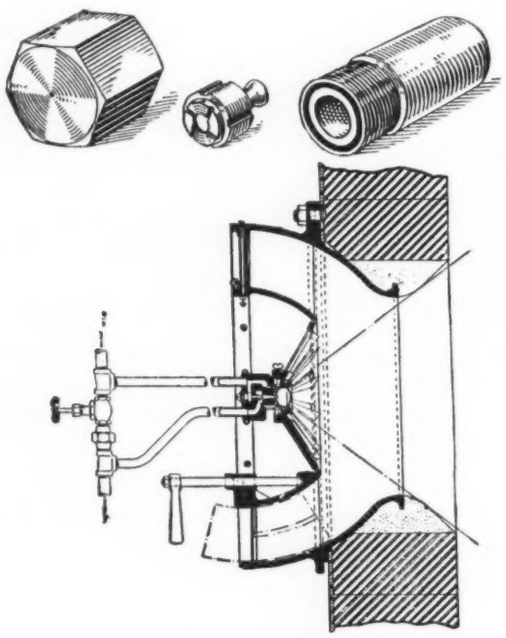


FIG. 4—ENGINEER MECHANICAL ATOMIZER

In the Tate-Jones mechanical atomizer, Fig. 3, the atomization is brought about by the oil entering the tip *C* through diagonal passages *B*. These streams of oil set up a turbulence in the tip cavity and give a hollow-cone form to the spray as it leaves the orifice.

As with most mechanical burners, this one is placed in a hollow sleeve terminating in a cone. Air enters through the openings in the sleeve and flows along the burner tube until it meets the oil spray. The main air charge enters through the adjustable air register and passes along adjustable vanes of such a form that the air is forced into the oil spray rather than merely flowing along the surface of the spray cone. The amount of air, as with most burners, is regulated by the register doors.

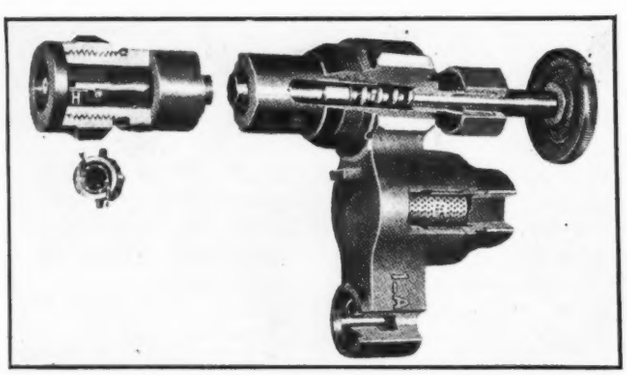


FIG. 5—COEN BURNER

The mechanical burner manufactured by The Engineer Co. uses the tip shown at the top of Fig. 4. Oil passes down the burner tube and to the recess around the atomizer, shown at the center. Flowing through the tangential grooves in the face of the atomizer plug at high velocity, it has a tangential movement as it enters the center cavity. The oil is thoroughly broken up into a mist and leaves the orifice of the tip as a hollow cone. The burner is provided with the air register, the angle of whose vanes is adjustable to give the correct draft and direction of air flow as in case of The Engineer's steam burner.

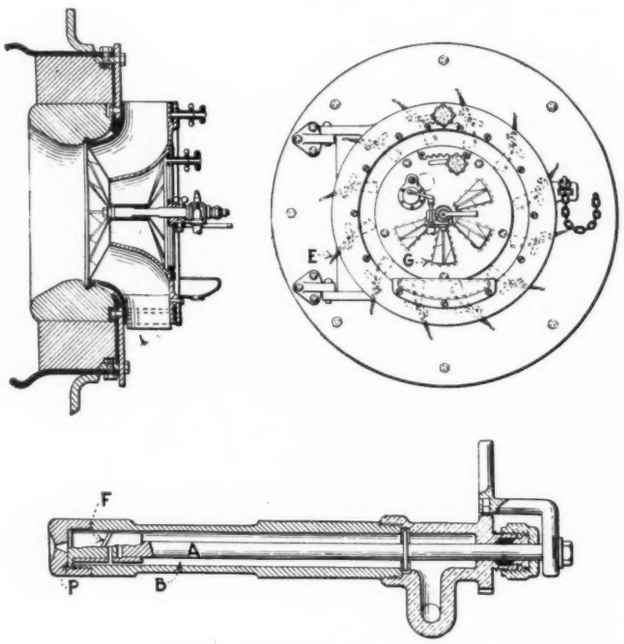


FIG. 6—MORSE BURNER WITH MOVABLE AIR VANES

The Bethlehem Dahl burner is shown in Fig. 1. Atomization is brought about by the tangential velocity of the oil entering the tip through the passages in the atomizer. The air entering the furnace must pass between the cone and the firebrick ring, and since the oil cone practically fills the ring opening, the air is forced through the oil spray. For primary ignition a part of the air is admitted through the slots in the cone and meets the oil as it issues from the burner tip. The proper location of the burner is obtained by the hand wheel and rack adjustment.

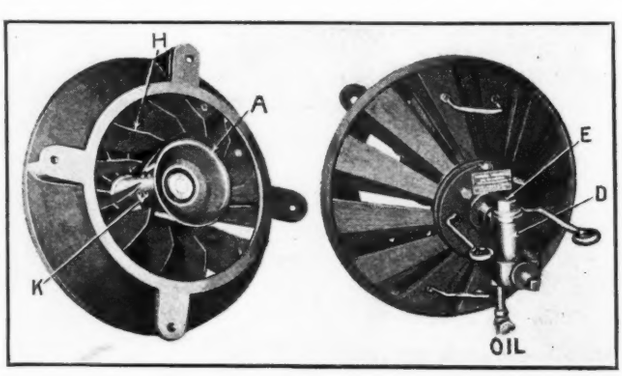


FIG. 7—WHITE MECHANICAL BURNER

For forced draft the furnace front is provided with ducts *D*. If natural draft is sufficient, the air box *C* is moved in against the front.

The drawback possessed by many mechanical burners is the oil-flow control. Where this is accomplished by a valve at or near the outer end of the burner, the pressure within the burner and at its tip is low on light load. The atomization then is more or less imperfect, and to eliminate this objectionable feature a number of burners regulate the oil flow by some control located close to the tip.

The Coen mechanical burner, Fig. 5, has a tip in the form of a hollow sleeve. The inner end of the regulating rod is slotted and fits into the tip *H*. By turning the rod the passage through these slots is made more or less as the load warrants. Full pressure is on the entire burner up to the slots, and since these are cut tangentially, the oil is given a whirling motion of practically the same velocity at all loads. The burner fits within an air register having a large number of vane blades to give the air its proper rotation.

The Morse Dry Dock and Repair Co. manufactures a burner (Fig. 6) wherein the oil flow is regulated by the adjustment of a sleeve *A*. This sleeve has a helical slot *F* and the amount this is uncovered by the top of the atomizer *P* controls the amount of oil entering the

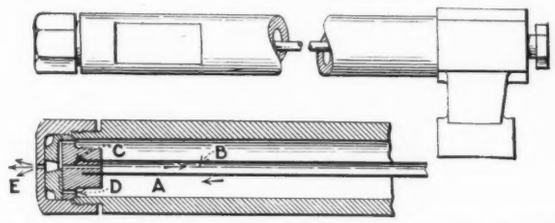


FIG. 8—SCHEMATIC LAYOUT, PEABODY-FISHER BURNER

passage from *B*. The tip contains a conical cavity ending in a small orifice through which the whirling oil issues. The burner is furnished with an air register having adjustable vanes *E* to give the air a directional flow through the oil cone.

The White burner, made by the Todd Shipyards Corp., is shown in Fig. 7 as assembled in the air register. The burner tip contains a cone having flutes cut in the surface at an angle with the cone. The passage of the oil through these tangential flutes sets up the desired twirling action. The fire cone or shield *A* carries a series of openings *K* which permit air to reach the tip and keep it cool. The vanes *H* are of a form that will force the air into the oil spray as the latter passes the cone. A screen or filter is placed in the head *D* and may be removed through the cap *E*.

In the Peabody burner the same amount of oil reaches the atomizing chamber at all loads but a bypass permits the escape of that portion of the fuel not required to maintain steam pressure. The oil flows down the inside of the heavy burner tube *A* and enters the atomizing chamber in the tip *E* through several small passages *C*, Fig. 8, which give the oil the necessary whirling motion. There is a small pipe *B* inside the burner tube, which connects with a series of holes in the burner tip. By opening a valve at the other end of this tube, part of the oil in the tip escapes through this pipe. This design enables the same amount of oil to reach the tip regardless of the load, so that there is no reduction in the oil pressure and the spray effect is practically constant for a large change in oil flow.

Marion Hopper-Feed Hand Stoker

The Marion Machine, Foundry & Supply Co., of Marion, Ind., has added to its standard Type C hand stoker the hopper feed shown in the accompanying illustrations. The feeding plungers are of box section minus the outer end and the bottom. The top plate of the plunger, forming the bottom of the hopper, rests

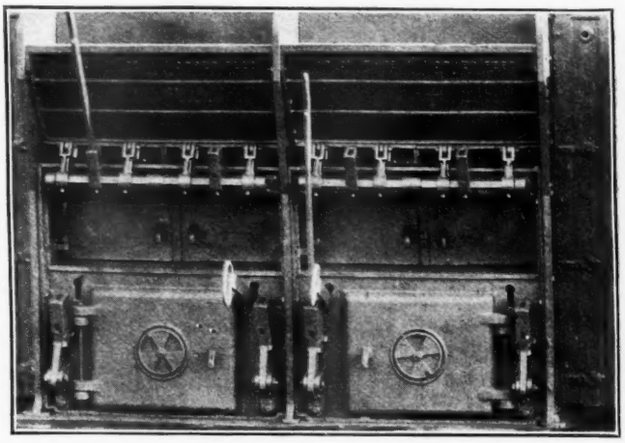


FIG. 1—MARION TYPE A HOPPER FEED STOKER

on a roller and to the same plate is attached the system of levers by which the plunger is moved back and forth to feed the coal as desired. There are two plungers per section of grate and both are manipulated by means of a short lever mounted on a shaft common to the two plungers. For each grate section this construction is repeated. Operating on rollers, the plungers move freely and the wear is reported to be less than with sliding plungers.

Another feature is the provision of firing and inspection doors immediately below the plungers, to be used

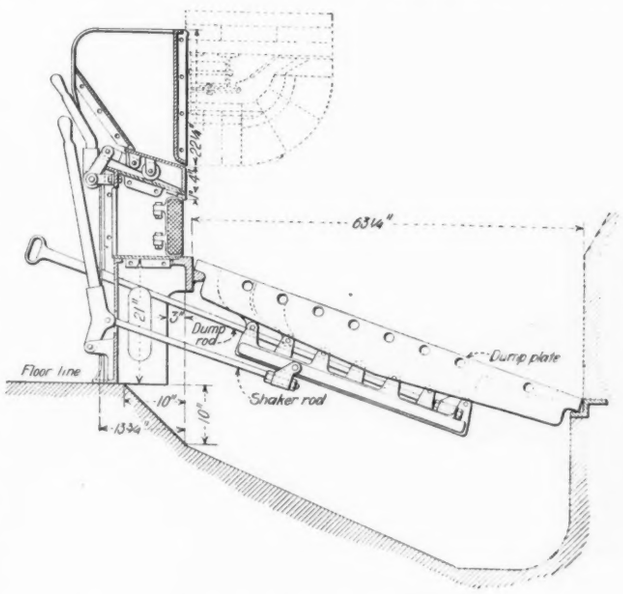


FIG. 2—VERTICAL SECTION THROUGH STOKER

as required. Features of the grate are bearings bolted to the frames, so that they cannot get out of position when stoking the furnace, and steel trunnions cast in the bars.

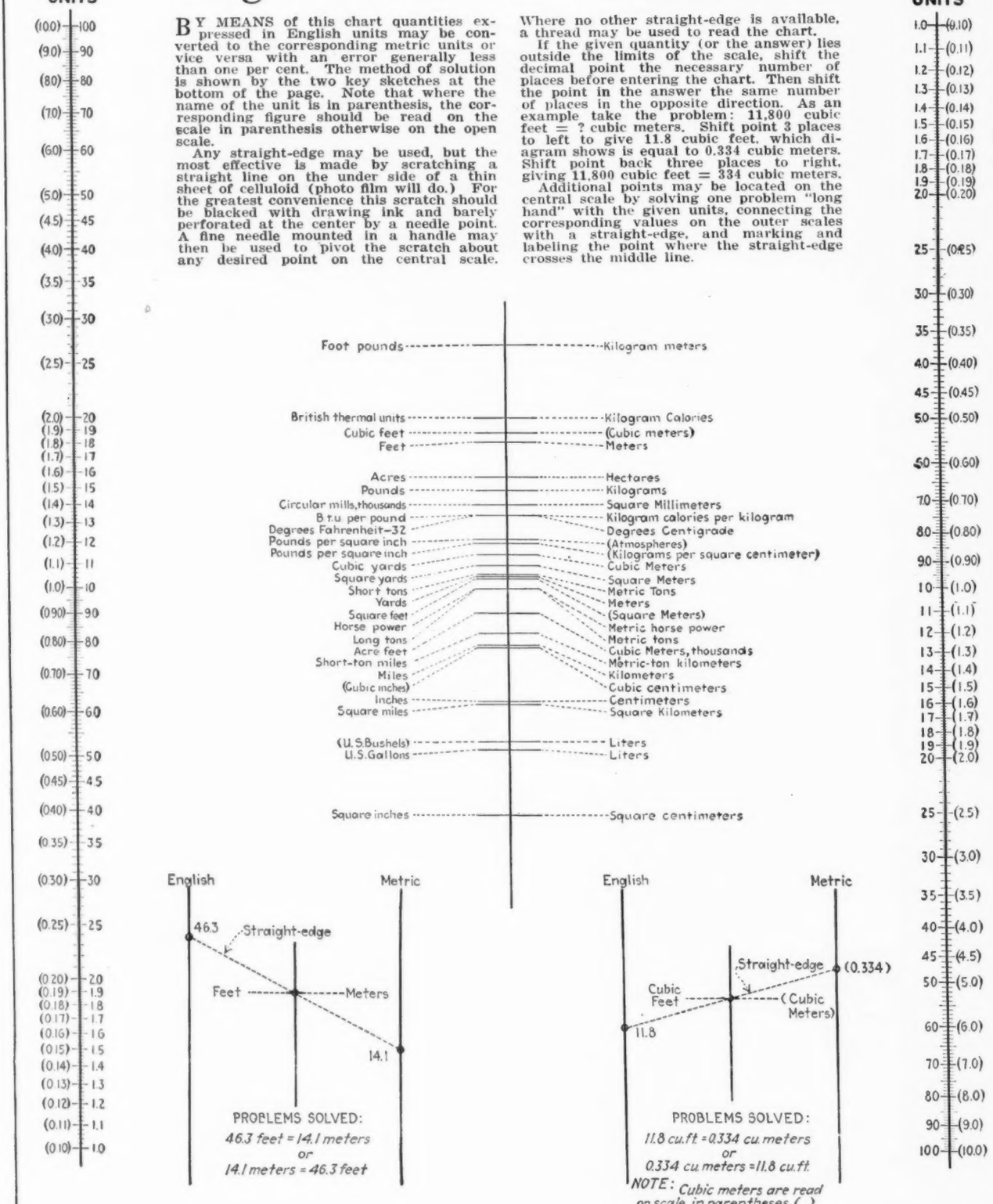
English-Metric Conversion Chart

BY MEANS of this chart quantities expressed in English units may be converted to the corresponding metric units or vice versa with an error generally less than one per cent. The method of solution is shown by the two key sketches at the bottom of the page. Note that where the name of the unit is in parenthesis, the corresponding figure should be read on the scale in parenthesis otherwise on the open scale.

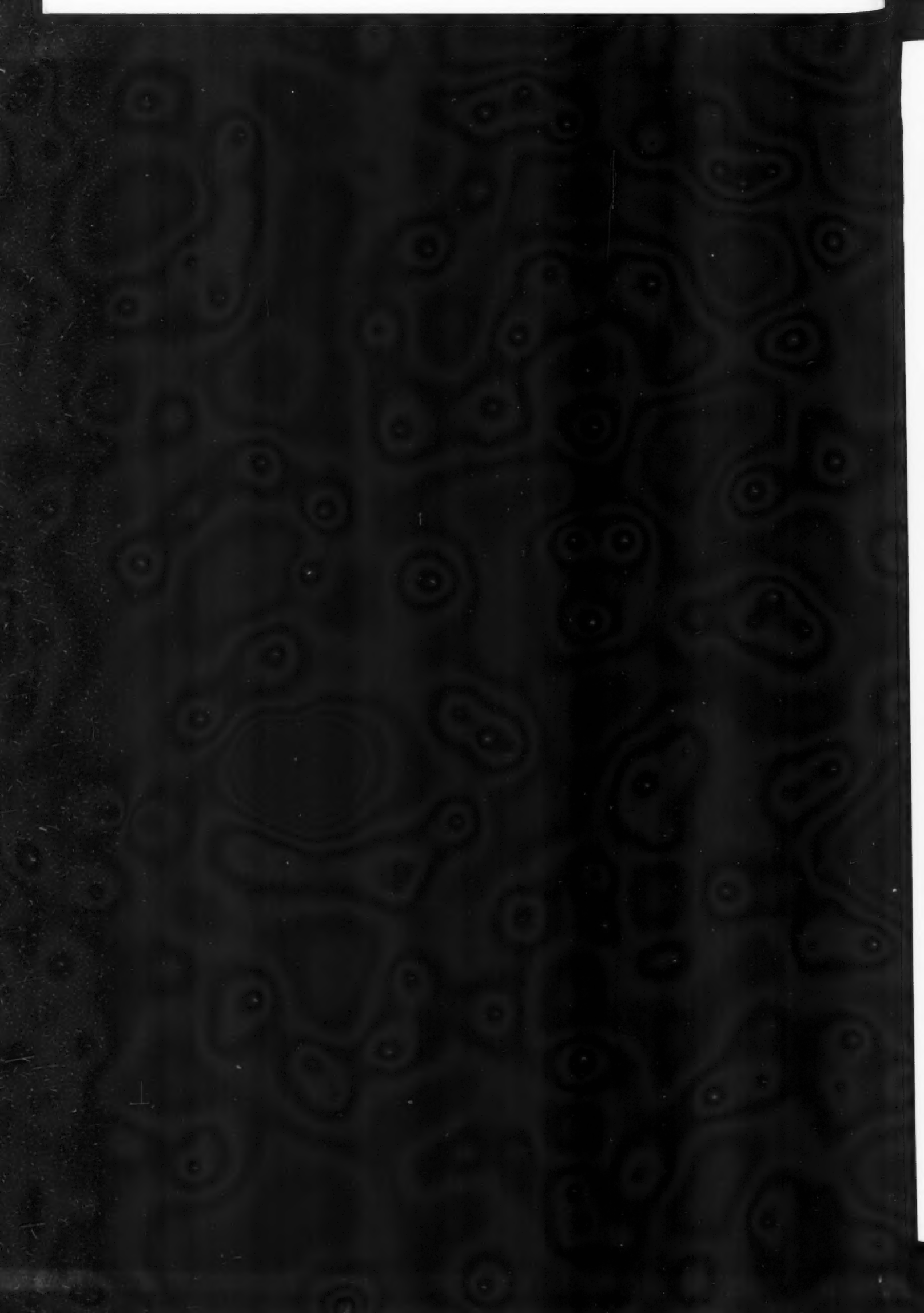
Any straight-edge may be used, but the most effective is made by scratching a straight line on the under side of a thin sheet of celluloid (photo film will do.) For the greatest convenience this scratch should be blacked with drawing ink and barely perforated at the center by a needle point. A fine needle mounted in a handle may then be used to pivot the scratch about any desired point on the central scale. Where no other straight-edge is available, a thread may be used to read the chart.

If the given quantity (or the answer) lies outside the limits of the scale, shift the decimal point the necessary number of places before entering the chart. Then shift the point in the answer the same number of places in the opposite direction. As an example take the problem: 11,800 cubic feet = ? cubic meters. Shift point 3 places to left to give 11.8 cubic feet, which diagram shows is equal to 0.334 cubic meters. Shift point back three places to right, giving 11,800 cubic feet = 334 cubic meters.

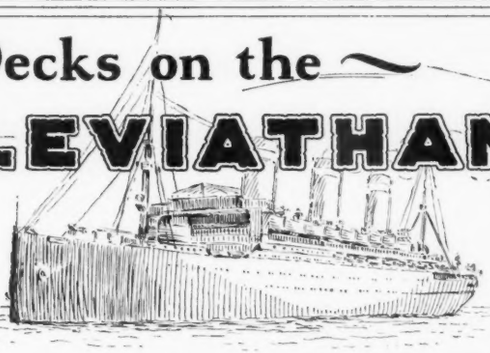
Additional points may be located on the central scale by solving one problem "long hand" with the given units, connecting the corresponding values on the outer scales with a straight-edge, and marking and labeling the point where the straight-edge crosses the middle line.

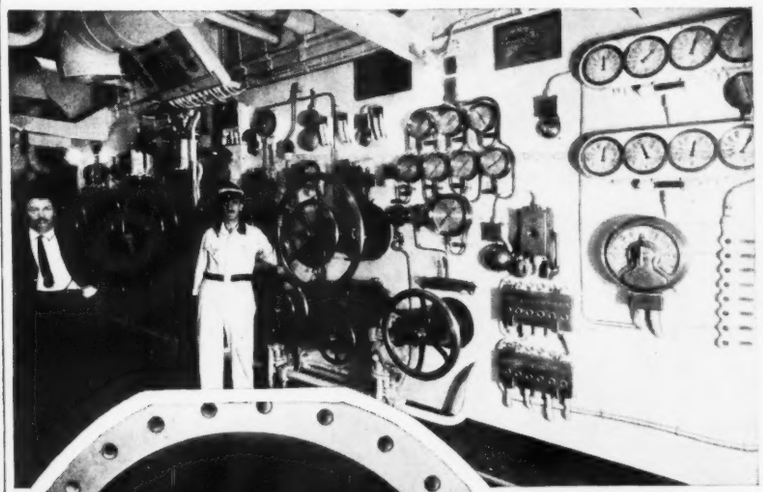


A few reprints of this diagram have been made on white bristol board. While they last single copies will be sent free, on request, to *Power* subscribers.

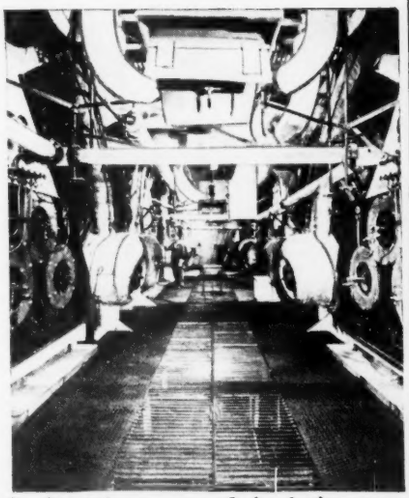


Below Decks on the 'LEVIATHAN'

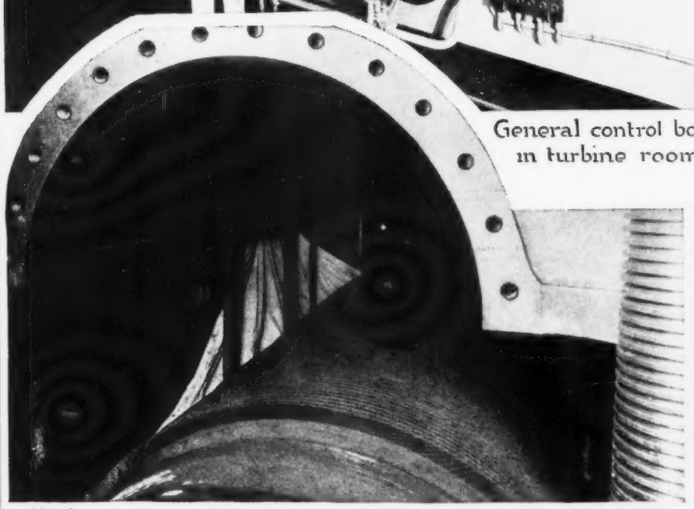




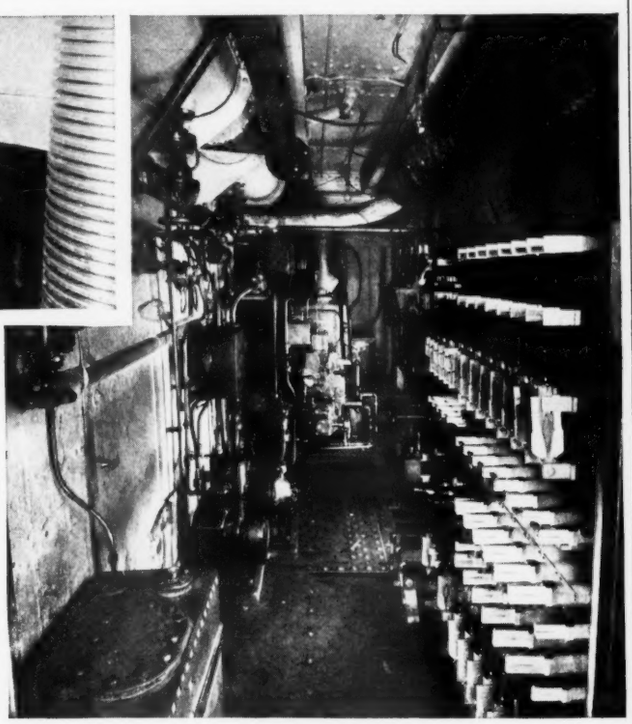
General control board in turbine room



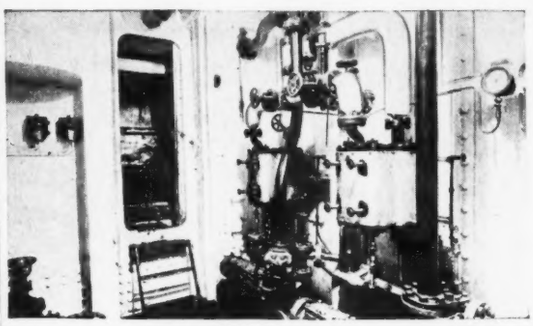
Looking down one of the boiler room aisles Note the oil burners



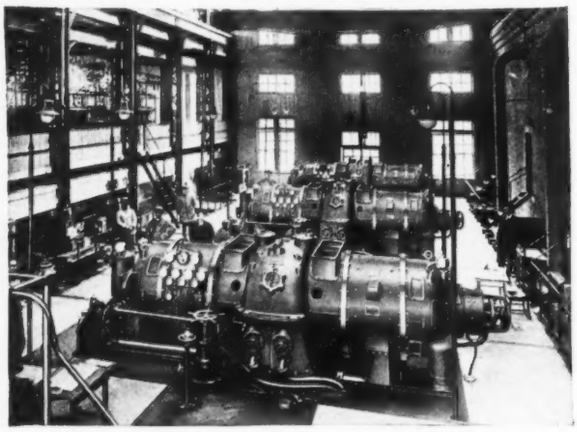
Turbine rotor with casing raised Note permanent lifting device



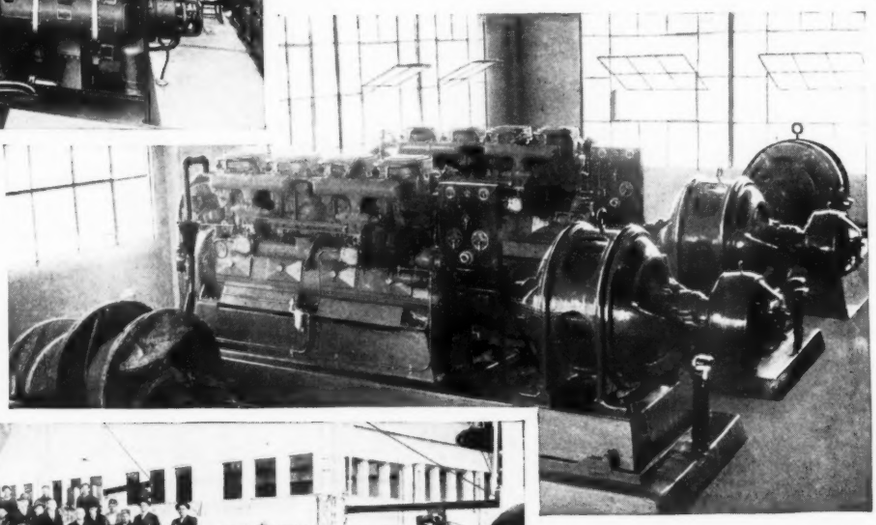
Diesel engine for auxiliary power and switchboard



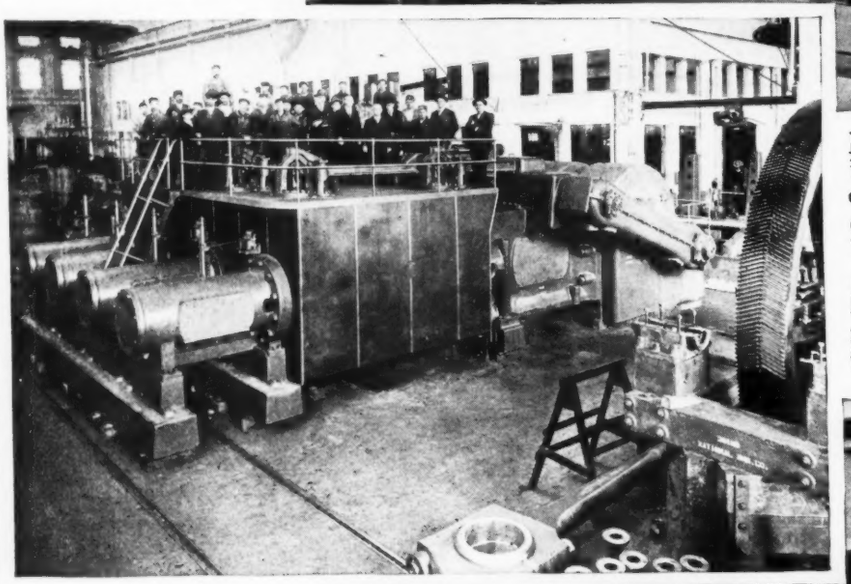
Fuel oil service pumps



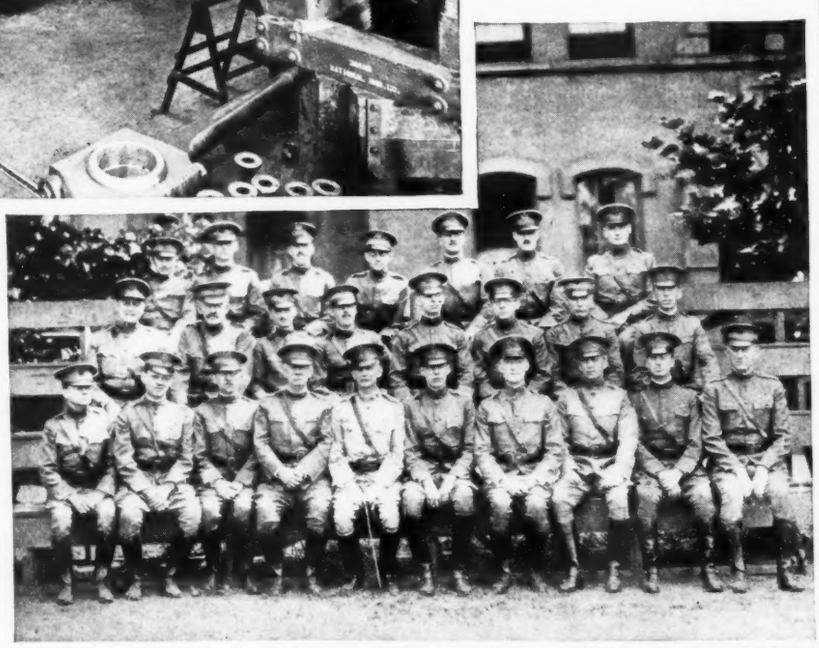
Station of the Hanshin (Japan) Electric Railway Co., showing three Stal (Svenska Turbinfabriks Aktiebolaget Ljungstrom) turbines of 4200 kw. capacity each. Running at 200 lb. 670 deg. cooling water at only 3102 kw. their average steam rate was 10.58 lb. per kw-hr.; a Rankine efficiency of 73.5 percent.



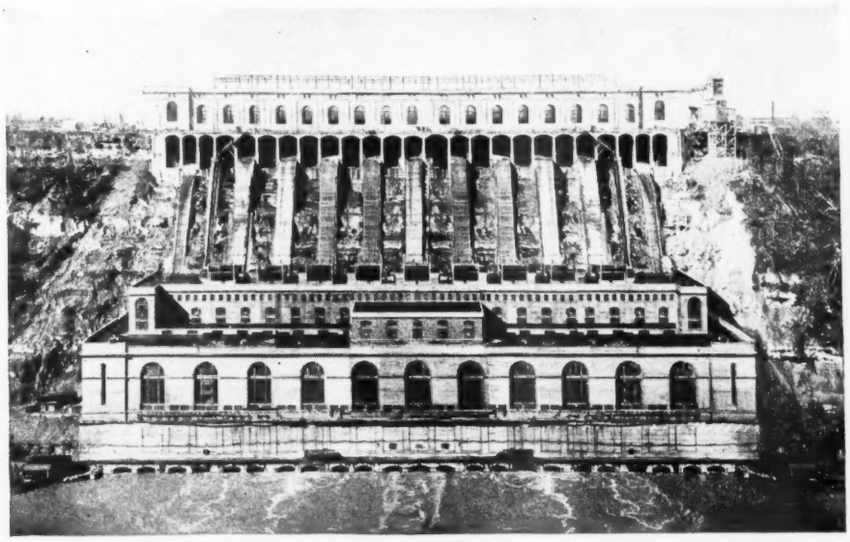
New Use For Gasoline Engines. Two 300 hp. Sterling 1200 r.p.m. eight-cylinder gasoline engines furnishing break down electric power at Comstock Mines Nevada.



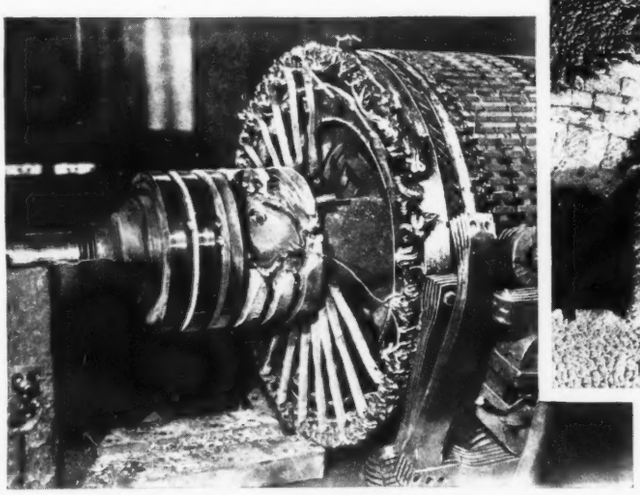
Here is evidence that the turbine has not entirely displaced the steam engine for large powers. The photograph shows one of two 25,000-hp. Nordberg uniflow engines recently constructed for the La Belle Iron Works



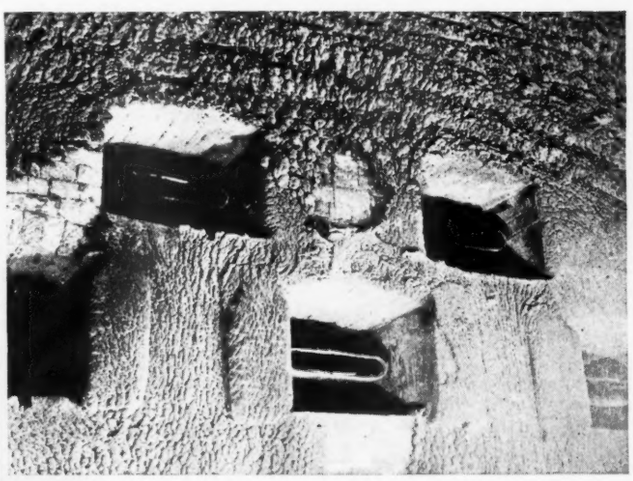
Reserve officers from Camp Dix on an inspection trip to Frankford Arsenal. The group contains several members of the American Society of Mechanical Engineers among whom readers will recognize Major Calvin W. Rice (fourth from the right, bottom row) Secretary of the A·S·M·E·



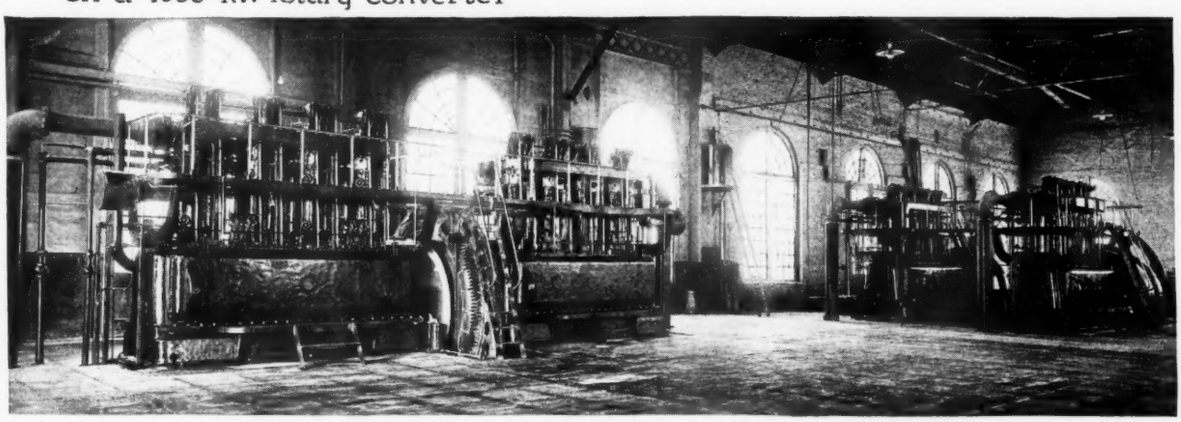
Latest View of the Chippawa-Queenston Development



A flashover caused this burnout on a 1000-kw rotary converter—



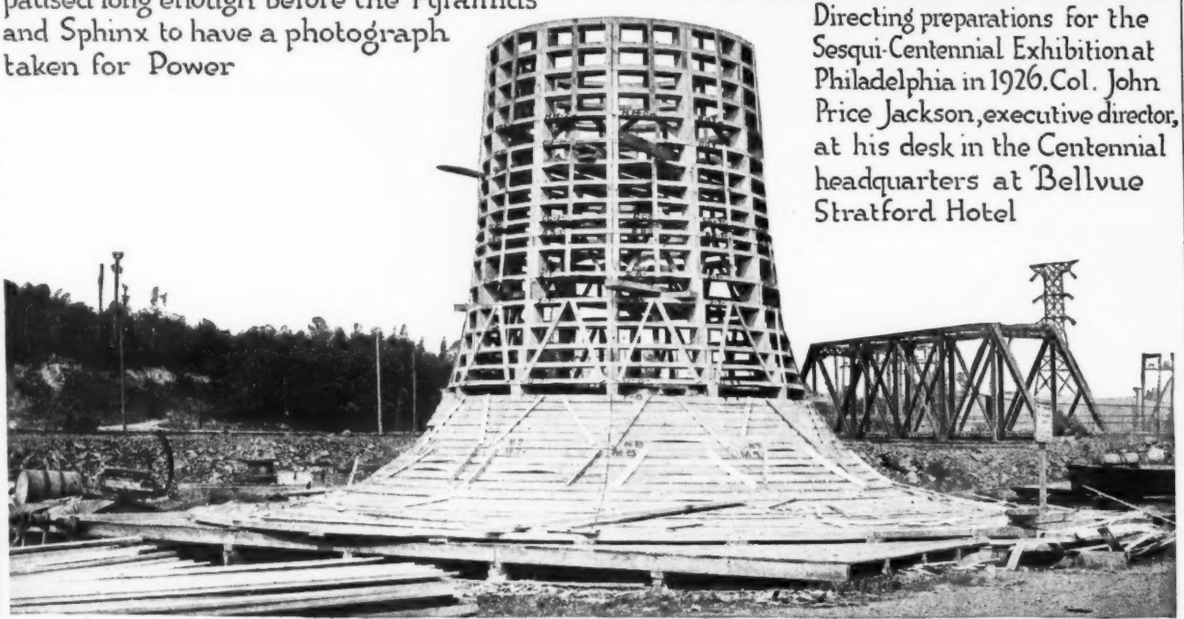
Interior of a pulverized coal furnace



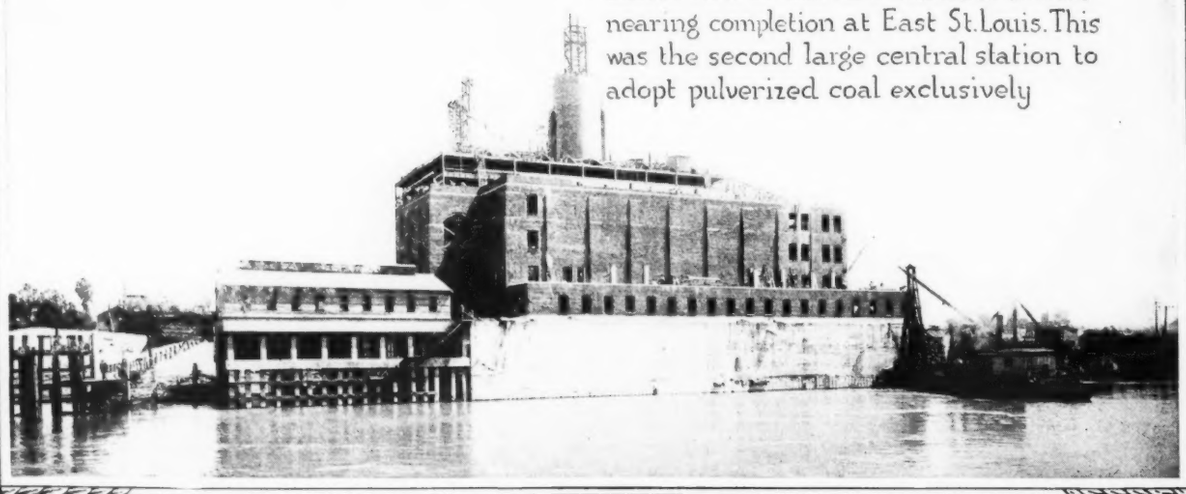
Largest stationary solid-injection oil engine in United States. Plant of San Antonio — Portland Cement Co. containing one 1000-hp. and two 480-hp. Ingersoll-Rand engines

J.W. Gardner, president of the Gardner Governor Co recently completed a trip around the world. He paused long enough before the Pyramids and Sphinx to have a photograph taken for Power

Directing preparations for the Sesqui-Centennial Exhibition at Philadelphia in 1926. Col. John Price Jackson, executive director, at his desk in the Centennial headquarters at Bellvue Stratford Hotel



A form for the draft tube bell of 41,000-Hp. turbine at Shawinigan Water & Power Co.



Latest view of the new Cahokia station nearing completion at East St. Louis. This was the second large central station to adopt pulverized coal exclusively

An Oil-Engine-Driven Ice Plant

UNTIL a few years ago it was necessary to have distilled water for ice making. There was little inducement to install economical engines since live steam was necessary for distilling purposes if the engine had a steam consumption of under 24 lb. per horsepower-hour. The advent of the raw-water ice system enabled plant owners to install economical units such as oil engines.

The fifty-ton ice plant of the Red Bank, N. J., Pure Ice Manufacturing Co. is an example of the success attendant upon the use of semi-Diesel engines for ice-machine drives. The plant is equipped with two 100-hp. Fairbanks-Morse semi-Diesel engines, each direct-connected to a 8¾x14-in. Worthington compressor.

An overhead countershaft is belt driven by the two engines through cutoff clutch couplings. Driven from the shaft are two Worthington 8½x9-in. air compressors which supply agitating air for the ice cans. In addition there is a small brine pump used to circulate the brine through the dehumifier, a small centrifugal water pump and a deep-well pump are also driven from the countershaft.

The engines are of the two-stroke-cycle semi-Diesel type, each having two cylinders 14 in. diameter by 17 in. stroke, and run at 257 r.p.m. The compression pressure is from 250 lb. to 280 lb. per sq.in., and as a consequence of this pressure the combustion-chamber metal need not be operated at as high a temperature as with most engines of this type. On low loads, when the mean cycle temperature drops, firing is assured by a deflector by which the oil spray is directed upon the uncooled starting plug.

The scavenging air is compressed in the crankcase on the down stroke of the piston until the latter nears the bottom center, where the ports are uncovered and the air rushes into the cylinder over the top of the piston. The shape of the piston head is such that the incoming air is deflected toward the top of the cylinder, resulting in scavenging of the burned gases, which pass out through the exhaust ports on the opposite side of the cylinder.

The main bearings are of the ring-oiled type, while the cylinder, piston pin and crankpin are lubricated by means of a mechanical oiler mounted at the governor end of the engine. Governing is accomplished by regulating the time of closing of the injection-pump suction valve, a separate pump plunger being supplied for each cylinder.

No air compressor for spraying the air into the cylinder is needed for these engines, as the injection nozzle breaks up the fuel sufficiently to insure good combustion. The engines are started by air at about 150 lb. pressure; this is stored in four tanks, which are charged by two Fairbanks-Morse type CC compressors belt-driven by two 3-hp. type gasoline engines. Air-kerosene torches are used for heating the starting tubes

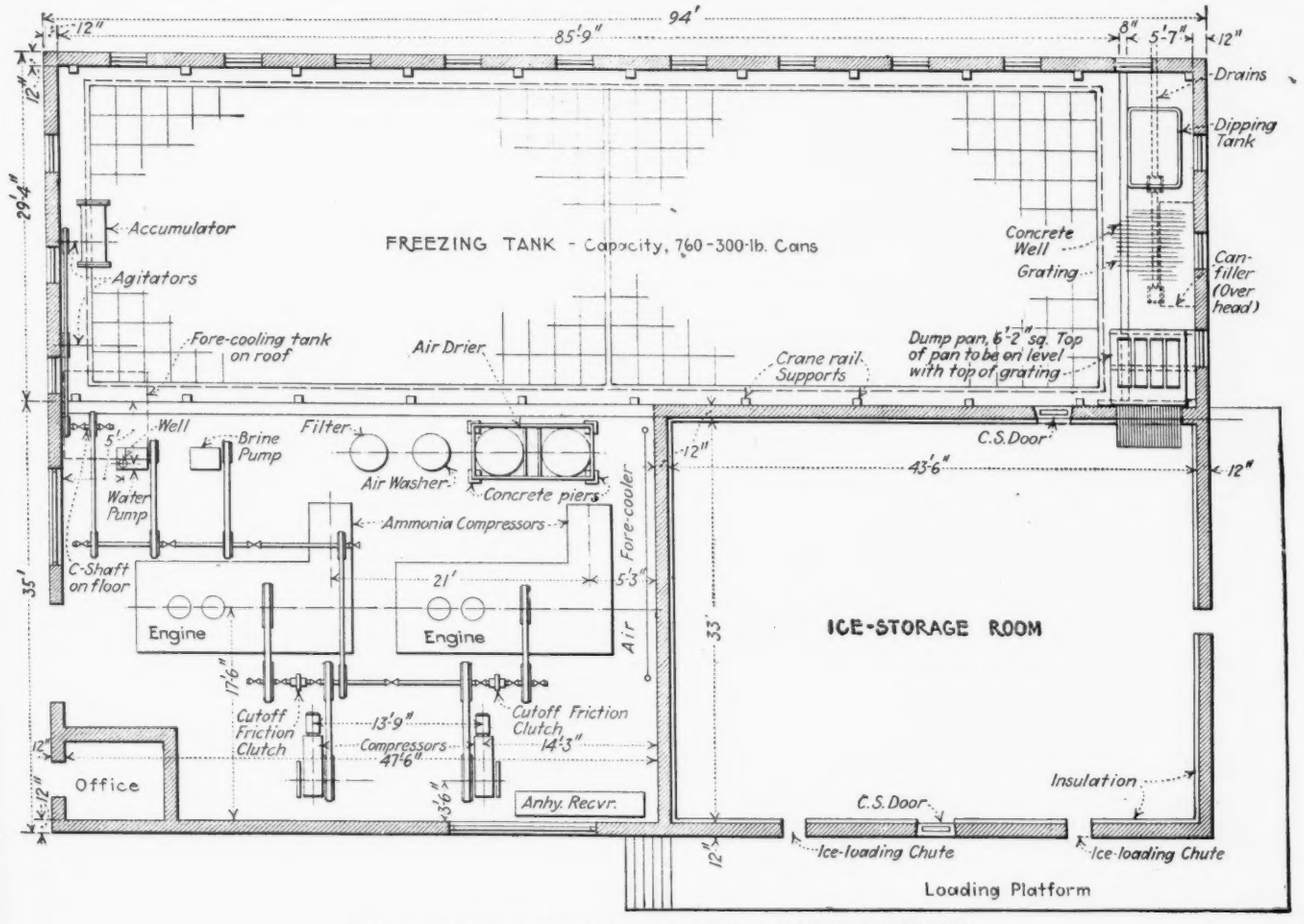


FIG. 1—PLAN OF ICE PLANT SHOWING MACHINF DRIVES

of the oil engines before the engines are started, but after the speed becomes normal, these torches are turned off, as the heat generated within the cylinder is sufficient for subsequent ignition.

The fuel used is a Pennsylvania gas oil of 36 to 40 Bé. gravity and costs 5½c. delivered. The consumption with both engines running during the heavy summer load averaged 13 gal. per hour; the fuel cost per ton of ice thus ranges from 25 to 30 cents.

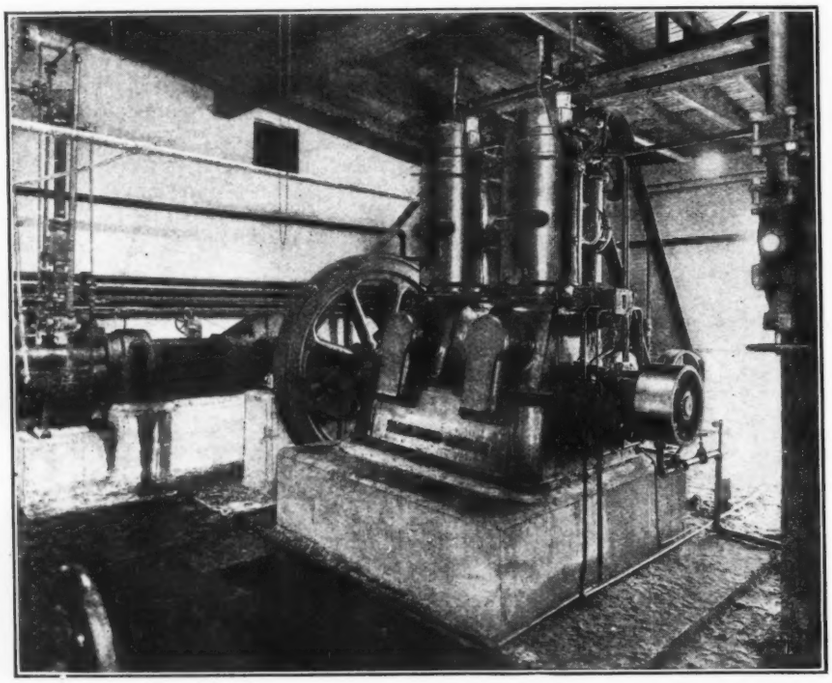


FIG. 2—100-HP. SEMI-DIESEL ENGINE DRIVING AMMONIA COMPRESSOR

No figures were available covering the lubricating-oil consumption of the engines, but in view of the fact that the oil used in the entire plant amounts to 50 gal. per 90 hours, the engines consume approximately 1 gal. per 400 horsepower-hours. No attempt is made to reclaim the crankcase drip, although this is being done in many plants and would result in a probable saving of 50 per cent.

The fuel is purchased in carload lots and flows by gravity from the car into an 18,000-gal. storage tank, from which it is forced by air pressure to the individual 200-gal. tanks that serve the engines. Pumps mounted on the engines pump the oil from these tanks to the small reservoirs that supply the oil for the injection pumps.

Arrangement of Muffler

Each engine is fitted with a cast-iron exhaust pot located at a short distance from the exhaust ports. These pots are connected to a 4x10-ft. steel drum buried outside the building; about 20 ft. of 10-in. pipe extends vertically out of the center of this drum and discharges the exhaust gases into a 30-in. iron stack which extends 20 ft. above the roof.

The deep-well pump delivers water at 56 to 60 deg. F. to the ammonia-condenser coils on the roof. After flowing over the coils, the water is collected and part of it flows by gravity to the cooling-water jackets on the engines. This makes a very good arrangement as the water supply is always assured at a constant pressure. The cooling-water outlet temperature from the engines is maintained at from 140 to 160 deg. F. From the engines the water is piped to the dipping vat, where it is used to free the ice cakes from the cans, after which it flows to the sewer.

That portion of the water from the condenser coils not required by the engine is pumped into a wooden tank of approximately 7,000 gal. capacity, in the bottom of which is about three feet of beach sand for filtering. From this storage and filter tank the water is drawn as needed into a cooler, where the temperature is lowered to about 40 deg. F. by means of ammonia gas flowing from the evaporating coils to the compressor. After being cooled, the water flows by gravity to the filling tank in the freezing room.

The ice cans, which are of 300 lb. capacity are piped for the agitating air and are handled with an overhead electric traveling crane. This air receives considerable attention after leaving the agitating compressors. It is washed, has its moisture removed and is chilled before passing into the headers which supply the ice cans. A pressure of 10 lb. per sq.in. is maintained on these headers, while the pressure at the compressors is about 35 pounds.

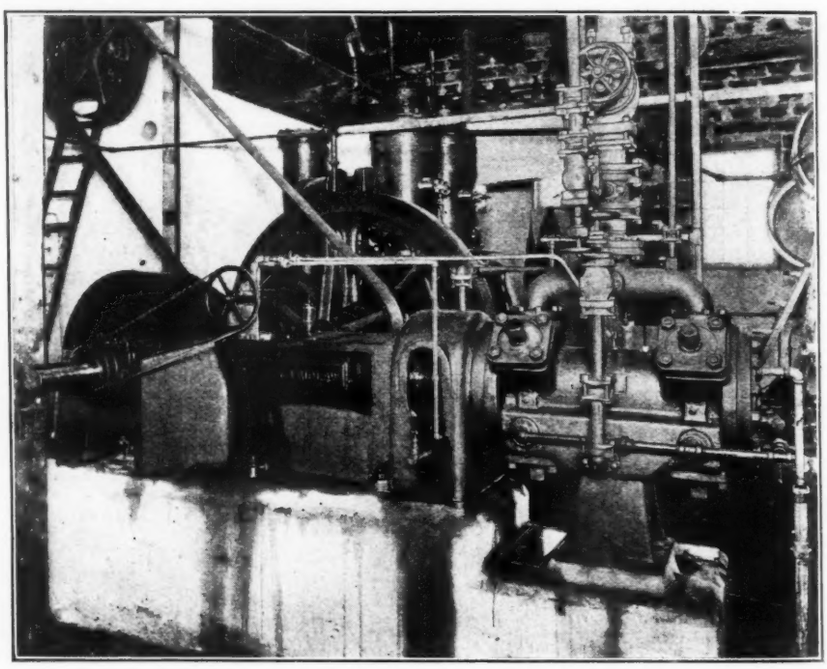


FIG. 3—VIEW OF ONE AMMONIA COMPRESSOR AND PIPING ARRANGEMENT

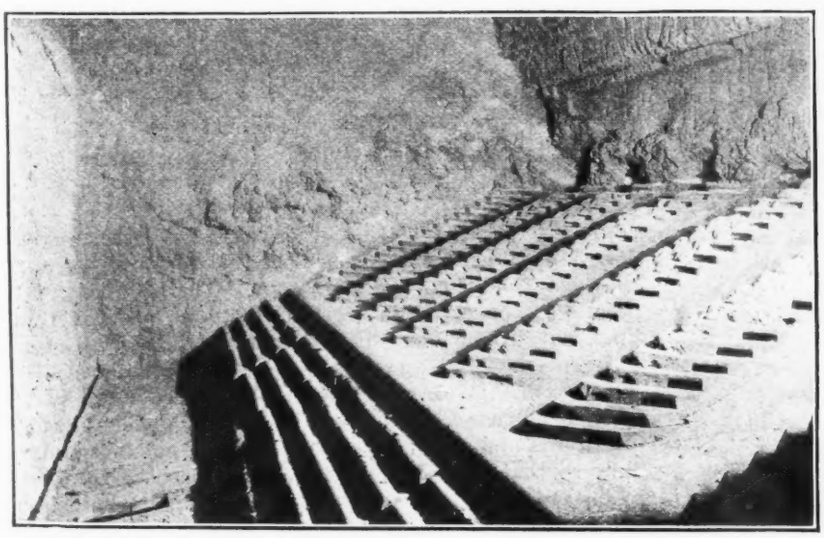
Approximately 125 ft. of 1½-in. pipe is used per ton of ice, the brine temperature being maintained at 20 deg. F. Normally, a back pressure of 15 lb. gage is carried, while the head pressure ranges from 150 to 180 pounds.

The ice-storage room is 33 ft. by 43 ft. 6 in. and is maintained at a temperature of 25 deg. F. by direct-expansion ammonia coils hung from the ceiling.

The plant was originally installed in August, 1920, but did not start full-time operation until May 5, 1921. On this date both engines were started and were run without either being shut down until Oct. 7, when one was stopped owing to a seasonal decrease in the demand for ice and through no fault of the engine. The second engine was kept in operation for several months with only short shutdowns for adjustment of the machinery.

Low Stoker and Furnace Maintenance

As an interesting example of what an underfeed stoker will do under a protracted period of severe service with a minimum expenditure for upkeep, the accompanying photograph is presented. It shows a 7-retort stoker under a 7,500-sq.ft. boiler. The unit was installed in December, 1920, in the plant of the C. R. Wilson Body Co. of Detroit, Mich. At the time the photograph was taken, the stoker had been in practically constant operation night and day for 25 months. During this time it had been down only twelve days for washing the boiler, being taken off the line as little as possible, as the stand-by unit was not large enough to carry the peak loads of the manufacturing plant.



APPEARANCE OF TAYLOR STOKER AFTER TWENTY-FIVE MONTHS OF CONTINUOUS OPERATION

From December, 1920, to December, 1922, the stoker burned 14,600 tons of coal plus 300 tons of scrap wood and iron to evaporate 145,999 tons of water. During the winter, for twelve hours of the day the boiler operated at practically 300 per cent of rating and for the 12 hours at night at 250 per cent of rating. In the summer months, the day load ranged in the vicinity of 120 per cent of rating and the night load approximated the nominal rating of the boiler.

As the company had no other means of refuse disposal, it was necessary to burn on the stoker all the wood scrapped in the process of body manufacture. When a partly completed body was rejected and scrapped, the metal and wooden parts were put into the furnace together. During 1921 several bodies and several hundred tons of iron had to be scrapped. According to the chief operating engineer as high as one-half ton of iron a day had been thrown into the furnace. The theory that iron and coal create a clinker was well brought out in this case, for whenever there was any iron in the furnace a clinker would arch from the bedplate of the stoker to the bridge wall, of such proportions that when the dump grates were dropped, the clinker would support its own weight and could not be broken by a slice bar. It required the use of the steam-operated dump grates on this stoker, which would rise above the resting level and break the back of the clinker, before it would drop down into the ashpit.

Maintenance Cost Small

During the 25 months' period of this severe service the total maintenance consisted in the replacement of a ½-in. pin that had sheared. The photograph shows one section of the dump grates burned out and five sections of the extension grates burned on the top row, which will require replacement, and a few of the tuyere noses burned off sufficiently to require renewal. The front wall will have to be built up for a distance of about 4 ft., but the side walls and the bridge wall will not have to be touched. It will be noticed that the dead plates representing the hottest part of the stoker are in good condition. This is attributed to the air baffle in the windbox turning the incoming air against the dead plate to cool it and at the same time preheating the air, which then circulates up through the tuyere boxes and out of the tuyeres into the fuel bed.

The condition of the front wall and the burning out of the top sections of the extension grates is attributed to the fact that the siftings had not been cleaned out of the upper tuyeres for two years and in collecting had got into the extension grates in sufficient quantity to prevent the air from circulating freely. It will be recalled that the usual period recommended for cleaning out the siftings is every three or four months.

As an explanation of the excellent condition of the stoker and furnace it was stated that the side walls were coated with high-temperature cement while the walls were warm. Applying cement in this way seems to prevent it from chipping off after the fire is started in the furnace. At the end of the 25 months the side walls and bridge wall were in practically as good condition as on the day they were coated. Close inspection of the photograph will show a 2-in. steam line embedded in the side wall along the side row of tuyeres with ¼-in. holes visible through each tuyere step. The sum of the areas of these holes equals the cross-sectional area of the pipe. Exhaust steam was passed through this pipe continuously, and it will be seen that the side tuyeres after two years of operation are in good condition. This operation was stated to have followed standard prescribed methods.

Accurate Methods of Aligning Steam Turbines; Taking the Sag Out of a Tight Line

By EDGAR G. BARKER, Sr.
Steam Turbine Superintendent, Beech Bottom Power Company

The sag of a tight line, when used horizontally, introduces an error into vertical measurements of alignment. Tables for finding the amount of sag are likely to mislead, as a difference in material of the wire, end supports, weights or other factors may produce sags quite different from calculated values. These difficulties may be avoided by neutralizing sag at the point of measurement. The method described is quickly and positively applicable at any point in a tight line for producing the correct distance for vertical measurements of alignment. A succeeding article will describe a method, developed by Mr. Barker, of making accurate micrometer measurements by means of sound.

A TIGHT line, when suspended vertically, represents a thoroughly accurate and satisfactory means for adjusting the alignment of machinery. When used in a horizontal position, however, it is equally satisfactory for the side alignment, but leaves a great deal to be desired in regard to measuring the vertical locations of the various members.

Obstacles in the way of obtaining a high degree of accuracy with a horizontal tight-line, are:

1. No matter how tight or how short the line, there will be a certain amount of sag to deal with. Atmospheric and other conditions tend to vary this sag.

2. The expansion of the micrometer or other gage

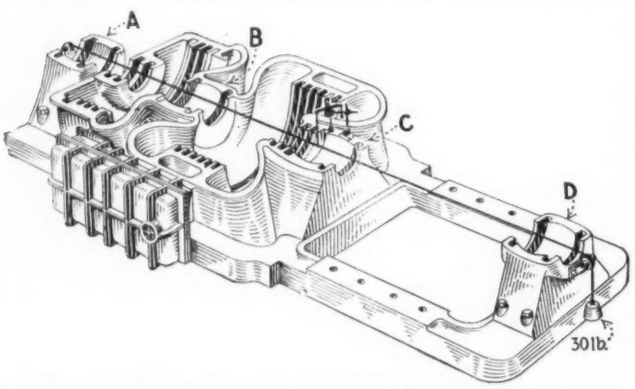


FIG. 1—HORIZONTAL TIGHT LINE EQUIPPED WITH A LIFTING DEVICE FOR ELIMINATING SAG

itself, due to the temperature of the hand, tends to produce an error of measurement.

3. The support at each end of the line may introduce a variable in the amount of sag. The usual support, utilizing a sheave wheel, for changing the vertical weight pull into the horizontal line pull, may contain appreciable friction. This would vary the line tension according to the direction of last movement of the roller before taking the measurement.

A common method of dealing with a sag is to calculate the exact amount in the line at the point of measurement, and shim up the bearing pedestals,

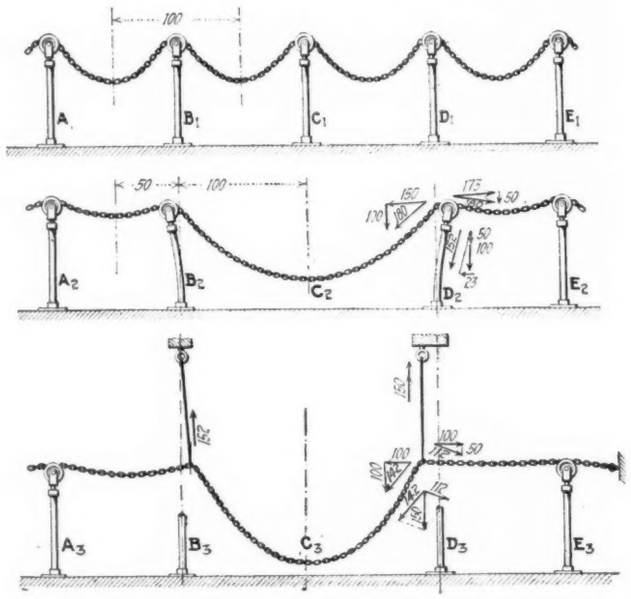


FIG. 2—SUPPORTED STRESS IS INCREASED BY SIDE STRAINS

cylinders, generators, or other elements accordingly. Many tables are published giving the values of sag for specified conditions of alignment. There is a great possibility of error in working with a table of this kind, due to the fact that the wire used may be of a different material and possessing different characteristics from that for which the table is calculated. Very often it is necessary to check alignment under difficult conditions and the proper material may not be obtainable, so that a good grade of fishline may be the best to be had. Another source of error is that the table, being calculated for average conditions, does not always hold equally well for a hot engine room at 110 deg. to 120 deg. F. or conditions encountered when a new machine is installed in winter in a structure that is in the process of being built, without heat, and at a temperature considerably below zero.

As an alternative to these uncertainties, it is possible to eliminate the sag of a tight line at the point of measuring by lifting up the line at this point with the proper amount of tension. Results in a great many practical applications indicate that this check is more desirable in some ways than the aforementioned methods. The tight line is placed over rollers at each end

of the machine to be aligned. The two ends of course, should be placed at the same elevation as determined by using a level and straight-edge or a surveying instrument. Even if they are not absolutely at the same elevation, applying the proper tension will, as a matter of fact, bring the tight line up to its correct alignment within the allowable or known error of the instrument used.

A convenient tight line is a steel music wire, 0.0166 of an inch in diameter, Washburn & Moen gage No. 2. This should be placed under tension by means of a 30-lb. weight as indicated in Fig. 1. A convenient lifting mechanism shown at bearing *C* is made up from a surface gage, a universal joint and an apothecary scale, and arranged to supply a tension equal to one-half the weight of the wire between the supports. After making the proper side alignment, the wire is then picked up with the proper tension at the point where it is necessary to make the vertical measurement. Care must be used to see that the lifting line producing this tension is in a perfectly vertical position. This apparatus may be used at any desired point on the tight line.

It is thus possible to lift up the tight line to a position where sag is exactly eliminated, for each vertical measurement. In making several measurements in this manner, trouble might be experienced by the lifting device becoming disarranged. It would also interfere with the side measurements. Therefore, the most practical plan is to determine the actual amount of sag in one operation at any desired point and then disconnect

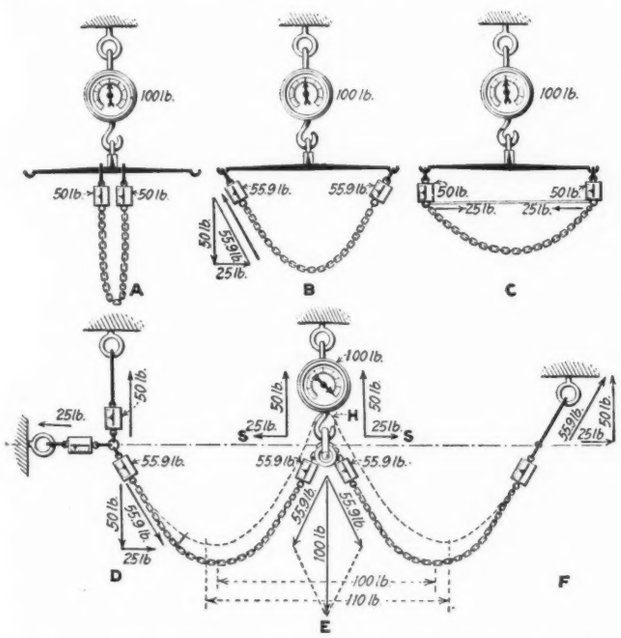


FIG. 3—VERTICAL SUPPORTS CARRY WEIGHT ONLY

the lifting device entirely, for ensuing operations, making allowance for the measured sag.

Fig. 1 shows the general arrangement of a four-bearing turbine generator unit. If the tight line is picked up at bearing *C*, which is approximately the middle of the unit, the question is, How much tension should be applied to bring the line to the same plane as the end bearings where it is supported? One would say, offhand, that one-half the weight of the horizontal length of the wire would be the proper amount of tension, since one-half of the span at each side would then be supported at this point. While this may be true, it may not be absolutely clear, and in order to make it so, considerable explanation may not be amiss.

In Fig. 2 there are a number of equally spaced supports which hold the chain by means of frictionless rollers, all of which are at the same elevation. The post *B*-1 is expected to support one-half of the span on each side, but on examining it closely we realize that the

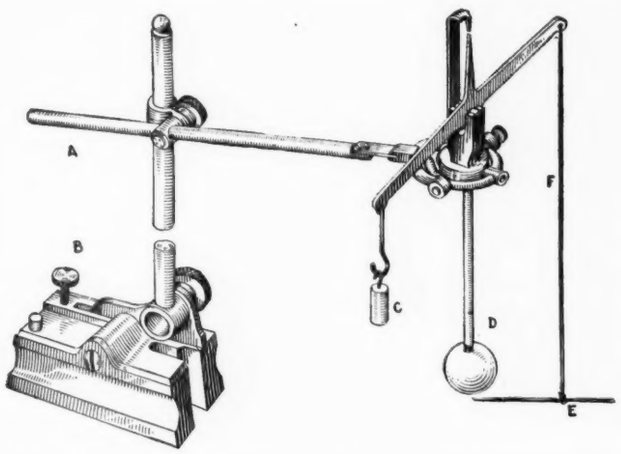


FIG. 4—SURFACE GAGE SUPPORTS APOTHECARY'S SCALES HELD VERTICALLY

chain pulls at an angle and not vertically downward. The oblique pull may possibly cause a greater tension than that due to the weights of the chain. It is easily seen, however, that the posts *C*-1 and *D*-1 will bear a weight equal to *B*-1, whatever this may be.

In order to clear up the question of oblique strain, which is the most confusing point, we will observe at *A* in Fig. 3 that a 100-lb. span of chain is hung up practically without side strain, so that 50 lb. is suspended at each end, giving a total of 100 lb. upon the scale above. It is understood that the beam, hooks and other parts weigh very little in comparison with the chain, so that their weight need not be considered. At *B* we see side strain introduced into the span. The force of 55.9 lb. pulling at an angle as shown would mean a 50-lb. vertical tension due to the weight and a 25-lb. horizontal or side strain. This would make a tension of 55.9 lb. actually supported by the end links of the chain. It is obvious, however, that the total weight is still 100 lb., shown on the upper scale.

At *C* we find the side strain eliminated by a light spreader whose weight is also negligible. In this case we shall easily realize that 50 lb. is supported at each end.

The conclusions drawn from these diagrams are that when a span is supported with each end at the same elevation, the purely vertical forces are due to weight alone, while the purely horizontal forces are due to a side strain tending to hold the ends separate. It is readily understood that if we wish to pull the length of the chain perfectly horizontal, it would require an infinite force in order to do this and eliminate absolutely all sag. Even with the infinitely great side strain the vertical strains would still represent only the weight of the span.

At *D*, *E* and *F*, Fig. 3, are shown connected spans suspended at the same elevation from equally spaced supports. We will readily see that 50 lb. is vertically supported at *D*, while at *E* there is 50 lb. due to each

span of vertical tension, so that 100 lb. represents the total vertical weight carried. The two side strains are in opposite direction and neutralize each other, indicated by arrows at *S*. At *F* the side strain is supplied by an inclined tie line.

If *D* and *F*, Fig. 3, represent end supports of the tight line, it will be readily seen that one-half the weight of the span between *E* and *F*, which totals 100 lb., must be supported in the middle in order to bring all three supports at the same elevation. It is realized of course that if this lifting force is exceeded so that it is 110 lb., the point *E* will rise to *H*, which is somewhat higher than *D* and *F*. The span would be changed as indicated by the dotted lines. The weight at *E* will then be 110 lb., indicated at the bottom. When it is considered that the weight, however, can be very accurately adjusted with a modern scale balance, it will be realized that a fair degree of accuracy can be obtained. This accuracy is much greater when the tight line is more nearly level or, in other words, more tightly drawn, so that a much less variation in height will cause a greater variation in vertical strain.

If we desire to lift up the tight line, however, at the bearing at *B*, Fig. 1, which is much nearer one end, the side strains are somewhat different and more confusing. In Fig. 2 the side strains *B*-2 and *C*-2 would tend to spread the posts as shown. These posts would then carry more strain than that due to one-half of the span on each side. This would be 152 lb., shown at *D*-2, instead of 150. If a rope is substituted, as in *B*-3, the side strain will pull it out of the vertical. The rope will, therefore, support two pounds more than the weight of one-half of the span at each side.

Now in order to avoid the effect of side strain, we shift the rope at *D*-3 to the left so that it is suspended vertically. The side strain due to the large span is therefore neutralized by tension in the short span between *D*-3 and *E*-3. The horizontal strains are indicated in the figure and are equal on each side of the rope.

From this illustration we may then conclude that the vertical rope at *D*-3 would carry a weight equal to one-half the span at each side and no side strain. A tight line, as shown in Fig. 1, with a weight equal to one-half of each of the spans *AB* and *BD* or, in other words, one-half the weight of the entire tight line between *A* and *P* would be required in order to bring this point to the proper elevation. Therefore, if the tight line is picked up *at any point* with a tension equal to one-half the weight of the line between the main supports and the lifting string is adjusted to a perfectly vertical position, which may require this to be tied on the tight line to prevent slipping, then we shall have the proper elevation at the point where the tension is applied.

Lifting Device Made from Surface Gage, Center Tester and Apothecary Scales

A standard surface gage makes a convenient means of support for the lifting device shown in Fig. 4. An apothecary scale is used to apply the correct lifting tension on the tight line. It is necessary to hold the apothecary scales in a vertical position, so that the pointer will remain vertical, and an accurate indication of correct weighing will be obtained.

In order to maintain the scale-holding device vertical, a universal joint is utilized, and a heavy weight *D*, suspended below the center part of this joint maintains a vertical position through gravity.

The vertical suspension element indicated in Fig. 5 is free to move in the universal joint to which it is attached. The apothecary scales are drilled to fit in the top of this element, as shown in the bottom part of the figure. The universal joint in this case was obtained from a No. 65 center tester, manufactured by the L. S. Starrett Co. A ¾-in. brass ball was used for the suspension weight. The universal joint was bolted to the extension rod on the surface gage. This gage can be placed at any point that it is desired to test the sag. It is only necessary to adjust the counterweight for the scale beams, which is applied to the tight line, which should be equal to one-half the length of the line between the end supports.

The tight line should be set up on the bearings of the machine by means of supports at each end. These may be raised or moved either to the right or left easily and accurately, by means of screw adjustments in preference to adjustments requiring hammering or knocking. The tight line of the kind previously described should be weighted with a 30-lb. weight at each end. The supports used by the writer each contain a ball-bearing roller over which the line can move with friction reduced to a minimum.

After centering the wire, by means of machined surfaces at each end of the unit in the usual fashion, the

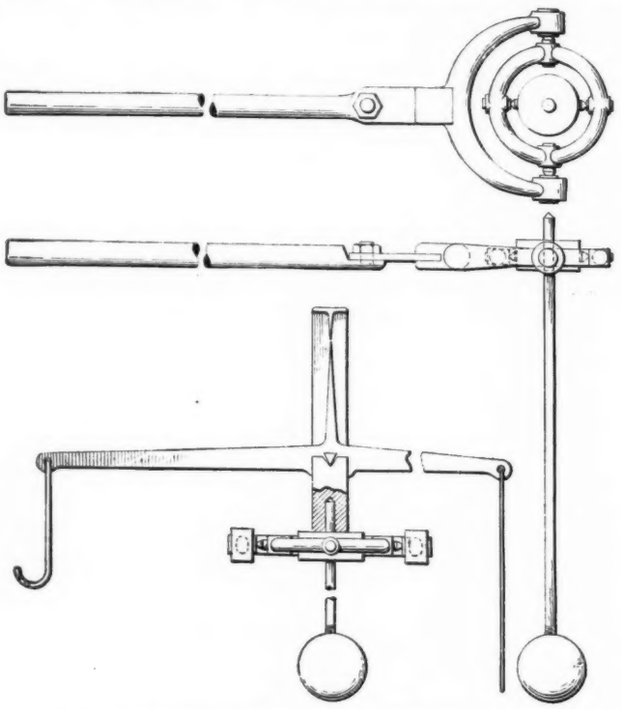
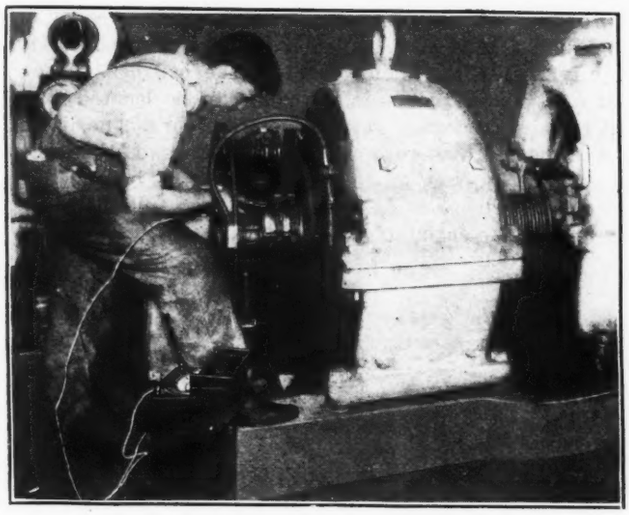


FIG. 5—SUSPENDED WEIGHT MAINTAINS A VERTICAL POSITION OF SCALE POINTER

amount of sag at each vertical measuring point may be found. It is only necessary to measure vertically to the tight line and then lift up at this point with the lifting mechanism and measure again with micrometers. The difference between the two measurements indicates the sag. A table of sag for the various measuring points can be quickly made up and used in making allowances during the remaining process of adjusting the alignment. Allowances for expansion and other conditions depend on the type and operating conditions of the unit. These should be accurately ascertained for locating vertical positions.



Locating Brushes on the Neutral of Interpole Machines

By B. A. BRIGGS

DIFFERENT methods of finding the neutral point on the commutator of interpole motors and generators are described. Other factors that must be considered to locate brushes properly are also discussed.

ON AN interpole direct-current machine the neutral position is more sharply defined than on the non-interpole type, therefore the brushes require to be set more accurately on the former than on the latter. On non-interpole machines the neutral shifts with the change of load, and it is sometimes necessary to shift the brushes back of the true mechanical neutral on a motor and forward on a generator to obtain sparkless commutation. With properly designed interpoles the commutating zone will be held at the true mechanical neutral, and on account of this zone being narrow, the brushes should be accurately located.

Before any attempt is made to set the brushes, it should be determined if they are correctly spaced around the commutator and that each set of brushes lines up with the segments, the latter being the first thing to check. It sometimes happens that, owing to a bent brush-holder stud, the brushes are out of line with the commutator bars, as indicated in Fig. 1. This can be checked by first carefully fitting all the brushes to the commutator and then trying to line them up with the same insulation segment, as in Fig. 2. Before the brushes are fitted to the commutator, all holders should be adjusted to within the same distance from the commutator. The distance of the holders from the commutator will vary somewhat with the type of holder, but in general will be from $\frac{1}{16}$ to $\frac{1}{8}$ in. The closer they are set to the commutator the less opportunity there is for the ends of the brushes to shift on the commutator.

To space the brushes equally on the commutator, first count the number of segments and divide this value by the number of poles, then space the brushes this number of segments apart. For example, assume a four-pole machine with 97 segments in the commutator; the brushes will be spaced $97 \div 4 = 24\frac{1}{4}$ segments apart.

Another method is to wrap a strip of paper around the commutator so that the ends overlap as in Fig. 3, and cut the ends on a mica segment so that the length of the paper will be the exact circumference of the commutator. The paper is then removed and its length divided into as many equal divisions as there are poles in the machines. These divisions are marked with a sharp pencil and the strip laid around the commutator again. With one end even with the edges of one set of brushes the edges of the remaining groups are adjusted to toe the marks. After the brushes have been properly fitted, lined up and spaced, they should be set on the correct neutral. There are a number of methods that may be used for this purpose.

The approximate neutral can be obtained by locating a coil directly under the center of an interpole and tracing one lead of this coil to a commutator segment. By shifting the brushes so that this segment comes directly under the center of a brush in one holder, they will be approximately on the neutral. It frequently occurs that this cannot be conveniently done on account of the difficulty in following the coil leads.

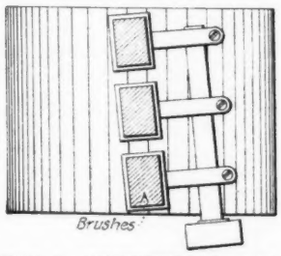


FIG. 1—BRUSHES OUT OF LINE WITH COMMUTATOR

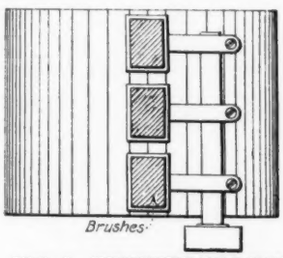


FIG. 2—BRUSHES IN LINE WITH THE COMMUTATOR

A method that is more accurate and does not require tracing the coil leads is to connect a millivoltmeter to contacts on two segments one pole space apart. This is best done by removing the brushes from the holders and substituting a fiber brush, Fig. 4, in a holder on each of two adjacent brush studs. Through the center of each of these brushes are copper rods in contact with the commutator. If the brushes are properly spaced, the rods will rest on segments one pole space apart. A millivoltmeter is connected to these contacts and the shunt field excited. By opening and closing the field circuit, a kick will be obtained on the meter if the brushes are off neutral. The brush-holders are shifted around the commutator until zero reading is obtained on the instrument, at which point the neutral is obtained. There is a slight error in this method due to the relative position of the armature slots to the poles, and it will be found that the neutral will shift slightly with a small movement of the armature. To get the brushes set accurately, the two extreme neutral positions can be obtained and the brushes set halfway between these two. Another objection to this method is that when the field circuit is opened the winding's

insulation is subjected to voltages that are considerably higher than normal.

The most satisfactory and accurate method is to take the drop of potential between segments. This may be done with a low-reading voltmeter and a pair of contacts set far enough apart to rest on two adjacent segments, Fig. 6. This exploring device is shown in Fig. 5 and is made of two pieces of rubber-covered wire about 8 in. long. To one end of each piece of the wire in soldered one end of a piece of lamp cord, the other end of which is connected to the low-reading voltmeter. The free ends of the wire are bared back about one-half inch and the two pieces taped together as in the figure. The best results can be obtained by running the machine as a generator, exciting it from an outside source and removing the brushes. Then move the exploring device around the commutator until zero reading is obtained, at which point will be the true no-load neutral of the machine. This should also be the full-load neutral if the interpoles are of the proper strength. The brushes can be placed in the machine and full load applied and the readings taken again. If zero reading is obtained at the same position as before, the interpole strength is of correct value. If the load neutral

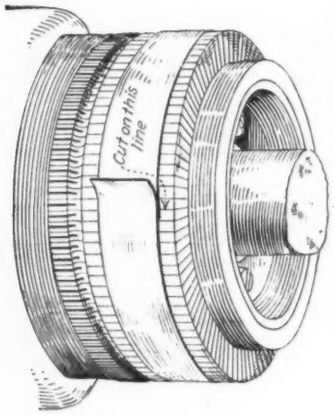


FIG. 3—STRIP OF PAPER AROUND COMMUTATOR TO BE USED FOR SPACING BRUSHES

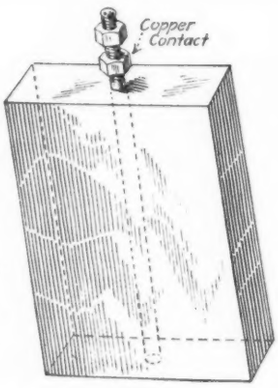


FIG. 4—FIBER BRUSH WITH COPPER CONTACT FOR LOCATING NEUTRAL

is found ahead of the no-load neutral on a motor and behind on a generator, the interpoles are too strong. On the other hand, if the load neutral is found behind the no-load point on a motor and ahead on a generator, the interpoles are weak. If the interpoles are weak, they probably can be strengthened by placing sheet-iron shims between them and the frames so as to reduce the air gap between the poles and the armature core. If this cannot be done the only remedy is to rewind the interpole field coils with a larger number of turns. Where the interpoles are too strong, it may be possible to make the necessary adjustments by removing shims from between the interpoles and the frame, thus increasing the air gap between these pole pieces and the armature. Another method would be to make up a German silver shunt of the proper resistance and connect it across the interpole winding terminals. On small and medium-sized machines, turns may be removed from the winding to give the proper strength to the poles.

In locating the neutral with the brushes in the holders, owing to the presence of circulating currents in the brush face it may be found that the neutral shifts slightly with a small movement of the brushes. However, after a few trials a position can be located that will remain stationary regardless of the brush position. Where the machine runs in one direction and the interpoles are too weak or too strong, it may be possible to locate the brushes on three-quarter or full-load neutral and obtain satisfactory commutation at other loads.

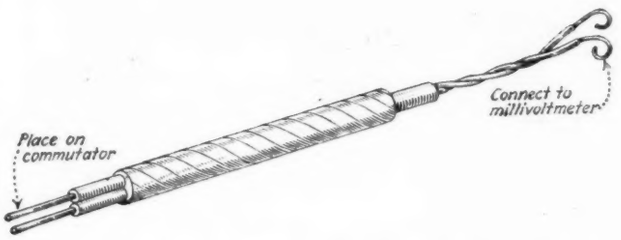


FIG. 5—CONTACTS USED WITH MILLIVOLTMETER TO LOCATE NEUTRAL POINT ON COMMUTATOR

Instead of the exploring contacts used in the foregoing, a fiber brush such as indicated in Fig. 7 is used. This brush has two holes bored in it from one end to the other, in which are placed two carbon or metal brushes to make contact with the commutator. The holes are located so that one contact will be slightly ahead of the other and rest on adjacent segments. The low-reading voltmeter is connected to the top of the contacts which are held against the commutator and the brushes shifted until zero reading is obtained on the instrument. This method has the advantage that the brushes move with the exploring device, but it also has the objection that a fiber brush is required for each size of brushes.

The foregoing discussion has been made on the assumption that the machine is symmetrical; that is, has its main poles and interpole equally spaced. Although this condition will exist in practically all machines, it will be a good idea to check it. The spacing between

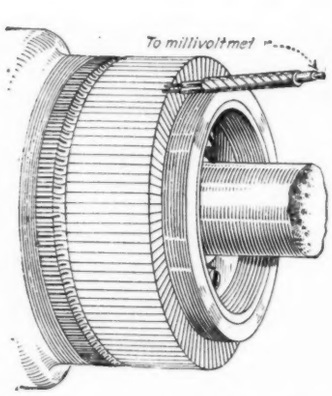


FIG. 6—CONTACTS ON COMMUTATOR TO LOCATE THE NEUTRAL ZONE WITH MILLIVOLTMETER

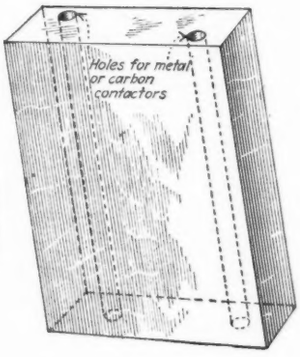


FIG. 7—FIBER BRUSH WITH CONTACTS FOR LOCATING NEUTRAL WITH MILLIVOLTMETER

the main pole tips and between the interpoles and main poles may be checked with a pair of inside calipers of the proper size. Another thing to be checked is the air gap. This is particularly true if trouble has been experienced with sparking at the brushes.

EDITORIALS

F. R. LOW, EDITOR

Unjustifiable Overhead Charges

FREQUENTLY, in figuring power-production costs, an obsolescence charge is included to safeguard against loss through the development of more efficient power-production apparatus which would render the existing equipment obsolete. Where the prime mover is a Diesel engine, however, such a charge is not justified. The Diesel has a thermal efficiency of over thirty per cent and delivers a horsepower on a consumption of less than eight thousand British thermal units. Since its inception no other heat engine has approached this value, and even the use of steam of three thousand pounds pressure with several hundred degrees of superheat cannot theoretically meet the efficiency of the working oil engine. Moreover, the efficiency of the oil engine has remained practically constant from the time of the construction of the first Diesel. The variation in fuel consumption between the engines built in 1904 and those being constructed at present will not exceed ten per cent, representing a decrease in fuel per brake horsepower per hour from forty-five to forty-hundredths of a pound.

There is often a disposition to set the depreciation of an oil engine at too high a value. There is no reason other than caution why the life should be set at ten to twelve years. Scores of these engines have been in operation from twelve to fifteen years with every reason to expect this will be doubled within the useful life of the machines. In fact, the Diesel engines that occasioned so much comment at the St. Louis World's Fair are still in service.

If a more reasonable view is taken of the depreciation chargeable against the Diesel and the idea of setting down an obsolescence charge is abandoned, the Diesel plant should show a total cost per kilowatt-hour of around seven mills.

Watch the Boiler!

POWER has recently published a number of short articles by David Brownlie, the well-known British expert on boiler testing and operation. Some of these were original contributions, while others were abstracts of articles published in British engineering journals. If the perusal of these leads the reader to believe that Mr. Brownlie is a man with one idea, he will not be far wrong. Mr. Brownlie has a big idea which is his constant theme, an idea worth repeating month in and month out until it has saturated the minds not only of the operating engineers, but of those business men whose domains include a boiler plant.

What is this big idea? Expressed in three words it stands, "Watch the boiler." Day by day the plant's money is being fed to it in the form of coal or fuel oil. In a year's time the fuel expenditure for a single boiler of moderate size may easily amount to several thousand dollars. Without constant vigilance it is practically certain that a substantial fraction of this sum will be wasted. Occasional tests made under ideal conditions may do more harm than good, if the engineer takes their results as an indication of every-day performance. The only safe procedure is to know day by day what each boiler is actually producing for the money expended. This implies continuous measurement of coal fired and water evaporated. These show the actual performance and hang out the red flag of warning when things go wrong. Important as is this warning, still more is necessary. The engineer must have reliable aids to tell him where the trouble lies and tell him at once, so that the remedy may be applied without delay. In this, such instruments as CO_2 recorders, draft gages and flue-temperature recorders render invaluable service.

All these things cost money, and here lies the rub. With his mind's eye the owner or manager sees a sheet of paper on which is written the various items of plant operation—so much for fuel, so much for labor, so much for capital charges, etc., and at the bottom a grand total which must be kept down to a minimum. He clearly sees that if instruments are installed, the capital charge item will increase; but his vision is dim on the fuel item, so he puts the quietus on the instrument idea with a "No, we can't afford it just now."

The whole trouble lies in this fuel item. In spite of all the evidence to the contrary the tendency to look upon it as a fixed quantity still persists. The owner must be made to see that ten, fifteen or twenty per cent can easily be knocked off his fuel bill by substituting knowledge for guesswork in boiler-room operation. When this lesson has been learned, the little sheet of paper will tell a different story.

Corrosion of Hydraulic Turbines a Problem of Economics

IN RESPECT to durability the modern hydraulic turbine stands as high as or higher than most types of power machinery. This is true even under the severe conditions these units frequently have to operate. In many plants using reaction-type turbines large quantities of foreign matter such as sand, silt, wood and ice, pass through the turbine. In order to keep these units in operation in the winter months, in some localities it is necessary to raise the racks and let large quantities of ice carrying foreign materials pass through the turbine. Even under these conditions, with few exceptions, the hydraulic turbine has been able to give a good account of itself.

The question of corrosion in the modern reaction-type turbine has become one primarily of economics. If the purchaser so desires, the manufacturers can choose a specific speed and supply a turbine that will be free from corrosion under the head and load for which it was designed. This turbine may have a speed below that which would be most economical to operate at, and it may be found cheaper to use a higher-speed runner which would result in a lower initial expenditure, but

would involve a somewhat higher maintenance cost due to the necessity of repairing or renewing the runner at intervals. In a plant where the units can be operated under full load continuously, durability of the turbine is of first importance. In such cases there is a market for every kilowatt-hour produced by the turbines, and when one has to be taken out of service it results in a loss in revenue equal to the gross return obtained from the output of the machine. When it is considered that at one-half cent per kilowatt-hour the return from a twenty-thousand-kilowatt unit operating at eighty per cent power factor is approximately two thousand dollars a day, the importance of durability is at once apparent. Where the water supply is subjected to periods of flood and low water, durability of the unit may be of less importance, as there are periods when some of them will be out of service owing to lack of sufficient water, during which periods they may be repaired without reducing the output of the plant. Such plants as these may be subjected to wide range of head due to flood water, under which conditions the design of the runner must be a compromise in regard to specific speed. If correct for normal operation, it may be unsuited to the heads during flood periods and corrosion will take place. The question here is also one of economics to supply a runner of a specific speed to meet the varied conditions that will produce a kilowatt-hour for the least capital outlay over a period of years.

Two Hundred per Cent On a Sure Thing

WHEN someone comes to a business man with a "sure" proposition to earn fifty per cent, one hundred and even two hundred per cent on an investment, the business man's training makes him instinctively react against it. Yet almost every business and almost every power plant holds such opportunities.

There are two respects, however, in which these investments differ sharply from stocks, bonds and real estate. The first is that while the value to the buyer is that of the fifty per cent, one hundred per cent or two hundred per cent investment, the value to the seller is but a small fraction of this, and is in general fixed solely by the cost of production and distribution, plus what modest profit competition will permit. Ordinary investment, such as stocks and bonds, are worth practically as much to the seller as to the buyer. This automatically serves to raise the price to such a point that the buyer receives only the normal return for the given class of investment.

The second fundamental point of difference is that the amount of money that any given investor can place at these enormous rates is strictly limited and usually fairly small. It is this that prevents plant owners from becoming millionaires over night.

As an example of an absolutely sure hundred per cent investment let us assume that X has a large oil tank outside of his plant, full of oil worth six dollars a barrel. Suppose also that this tank has sprung a leak, through which oil is wasting at the rate of a barrel a week. He is then losing $312 a year. If, now, a tank builder undertakes to repair this leak for $312, it cannot be disputed that the investment of that sum by the plant owner will yield a return of one hundred per cent on the investment. The contractor might raise his price to $3,120 and still give the owner a good 10 per cent on his investment. He will not do so, for the simple reason that some other contractor would step in and offer to do the job for $312 or thereabout, assuming that this figure represents the average contractor's cost, plus average profit. The job is worth $3,000 or more to the purchaser, but to the seller it is worth only what it costs, plus the profit that competition will allow. Again it should be noted that while the purchaser is offered this bona fide one hundred per cent investment, he is absolutely limited to $312 in the amount he can so invest. As has already been pointed out, this limitation on the amount that can be invested in characteristic of all opportunities of this type.

In almost every plant there are a few opportunities for two hundred per cent investments, a few for one hundred per cent, a few for twenty-five per cent, and so on down the line. Often those at the lower rate involve larger sums and greater total profits.

It is self-evident that the owner should begin spending his money at the point where the percentage of yield will be highest and then take the next highest, and so on. Perhaps the plant has been so carelessly managed that there are bare steam pipes that it would cost five hundred dollars to insulate in good shape. This investment should be made at once and will probably pay at least two hundred per cent yearly. This leak having been stopped, the chance for further two hundred per cent investments is ended. The next best opportunity may be to replace a lot of faulty traps that are leaking their own value in steam every year. The next batch of money should go to the limit into this one hundred per cent investment. All opportunities for two hundred per cent and one hundred per cent investments having been exhausted, the owner must look farther down the scale. Perhaps the next thing will be a complete stoker equipment that will pay, say, twenty per cent. This looks small after two hundred per cent and one hundred per cent, but the amount that may be so invested may be so much larger than that investable in pipe covering and traps that the total advantage gained may be far greater.

In this way he keeps on down the line until he reaches a level of net returns equal to that obtainable in the open market on investments of the same degree of safety. At that point, and not before, the wise business man stops, knowing that he has made the wisest possible use of his money.

Is He Going To Get Away With It?

SECRETARY WORK fired Arthur P. Davis after forty years of self-sacrificing devotion to the government service.

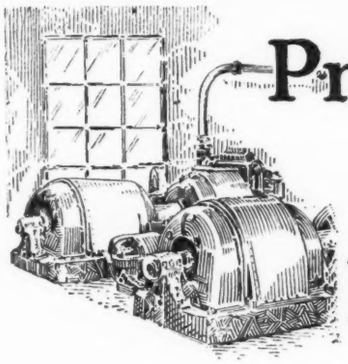
The civil-service regulations were gotten around by abolishing the office of Director of the Reclamation Service, which Arthur P. Davis, eminent engineer, held, and creating the office of Commissioner, which was given to Dave Davis, practical politician.

If one who has put his life and heart into the government work is to be made the victim of such petty politics, what incentive is there for the engineer to devote himself to the service of his country?

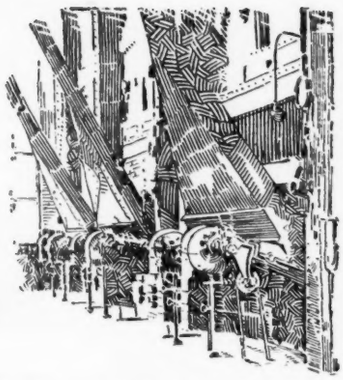
The way to discourage this sort of thing is to make the odium of it so react politically as to more than offset the advantage sought.

Let Secretary Work and those who put him up to this job know that he has kicked into a hornet's nest.

Be a hornet!



Practical Ideas *from* Practical Men



Air Hammer Saves Time in Reblading Steam Turbines

The reblading of steam turbines, especially in large power plants, appears to be one of the most monotonous and tiresome jobs in connection with their reconditioning. This is especially objectionable in the hot summer months, when the intense heat of the turbine room makes it impossible to work as steadily as under ordinary conditions. It is usually necessary to hustle with two crews of men, one for the day shift and one for the night, till the machine is ready to go on the line again.

During the last five years, in which I have been employed in a large central station, all of the units, four in number, have been taken out of service for entire or partial reblading. Engineers sent up by the leading manufacturing companies have superintended the work, which was done by the men of our own plant. It has always been a continuous pound and hammer until the new buckets were completely installed. This is not a soft job in the dead heat of the turbine room. The average engineer or mechanic would keep at it however until the work was completed, because he realized the necessity of speed when an expensive unit and the equipment with which it is connected, are out of service.

In reblading a 2,500-kw. impulse turbine a small air hammer was tried in place of the hand hammers for driving blades both out of and into the dovetail slots. This operated at 90 to 100 lb. pressure furnished by the station air compressor. The usual long, curved, blunt driving tool was dressed in a lathe so that it could be adapted to the air hammer.

It was found that the air hammer did excellent work in removing the blades through the dovetail slots, to the openings where the blades could be removed. It also acted as satisfactory in replacing the blades. However, the tool battered up the backs of the buckets to some extent. In order to eliminate this, one of the old buckets was filed down until it fitted loosely in the dovetail groove. The latter was well oiled. The new bucket was then given a little start into the dovetail groove with the hammer and the old bucket was placed directly back of it to receive the remainder of the air hammer blows. After this bucket had been driven completely around the rotor, it was slightly tight in the dovetail fit, which represented a better job than would have resulted if driven up by hand. The new bucket was not marked in the least, and the old one was available for use in installing the next blade.

After several buckets had been thus installed, it was found that more than one blade could be driven up at a time. Three or four buckets were then inserted in one operation, conveniently. After 8 or 10 driving operations the old bucket which was used to receive the air hammer blows appeared to be severely worn and beginning to break. A dummy bucket was then made of hard steel filed up to fit the groove loosely. This stood up much better than the usual bucket, which was made of bronze and seemed entirely too soft for this purpose.

By properly using this method, it is quite probable that the entire turbine could be rebladed on the average of one bucket every 40 to 60 seconds, which would save much time and labor. If any of the readers of *Power* decide to try this way of reblading, I am sure they will find it advantageous, not only in the matter of saving time and labor, but also in securing a better job in the end than by driving up by hand.

PIERCE D. O'CONNOR, Turbine Operator,
Utica, N. Y. Utica Gas & Electric Co.

How Air Affects the Operation of Centrifugal Pumps

Anyone who operates centrifugal pumps knows how necessary it is to see that a pump is thoroughly primed before starting, and yet many pumps run day after day with an air pocket in the eye of the impeller, and this air pocket does not always become diminished as time goes on. The air pocket does a great deal of harm, reducing not only the capacity of the pump, but also its efficiency, because with the reduced area the flow lines cannot follow the paths intended by the designer.

I have known cases, however, where air pockets would reduce the noise in a pump troubled with cavitation, and although I have no data to prove it, there might be some possibility that the efficiency could be better. This, of course, would not happen with a properly designed pump.

One case that I know of, formed air pockets in the following way: The pump was located about five feet *below* the supply water level, which would lead one to believe that priming troubles and air would not be encountered. But when the pump was started, friction in the suction line and the head required to produce velocity were sufficient to cause a vacuum to exist at the intake of the pump. This vacuum, together with a slight leak in the pipe line, caused considerable air to reach the impeller of the pump. Ordinarily, a pump would lose its prime under these circumstances, but such was not the result. Instead, the air pocket reduced the pump's capacity to such an extent that the water flowed again under its own head. Immediately the inflow of air had to stop, and the pump would continue to run at the reduced capacity.

A common cause of air pockets is a high point in the suction line. Then, when the pump is primed, air remains at the high point and lodges in the eye of the impeller as soon as flow begins. A condition of this sort can usually be avoided by properly installing the pipes in the first place, and a faulty suction line is usually worth replacing at almost any cost.

A good way to remove this air from a pump that apparently is thoroughly primed, is to shut down after running a few minutes and then to reopen the pet cocks and relieve the air. It is well to repeat this until no more air is present. RUSSELL K. ANNIS.

Mount Clemens, Mich.

Repair to 3,500-Kw. Horizontal Turbine Shaft

The description of this repair will no doubt be of interest, as it is thought to be somewhat different from anything before tried on a turbine shaft of this kind.

The trouble originated in the locknut holding the thrust collar on the high-pressure end of the shaft (as shown in the lower left-hand view, Fig. 1) working loose and causing the setscrew that had been previously countersunk into the threads on the shaft to strip them as the nut worked off. This left a clearance of about $\frac{5}{16}$ in. in the thrust against the 0.008 that is normally carried. After the bearing was dismantled, this thread was found to be so badly gone that it was impossible to fit another collar to it. It was decided to attempt to make the repair without replacing the shaft, although this method was not advised by the builders.

To effect this repair, an especially shaped tool was bolted to the face of the bearing and the shaft rotated

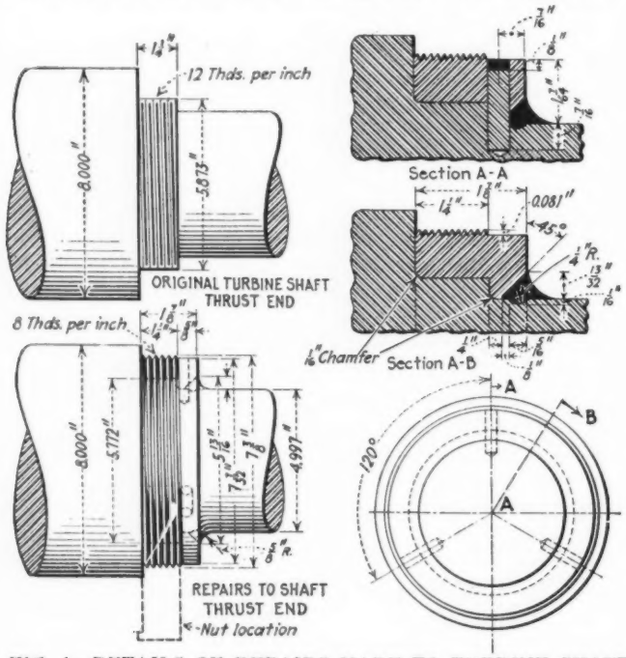


FIG. 1—DETAILS OF REPAIRS MADE TO TURBINE SHAFT

by a line applied to the coupling between the turbine and the generator and operated by means of the hoist from the traveling crane above. The old thread was entirely removed and the shaft turned down about $\frac{1}{16}$ in. below the original diameter of the root of the thread, or a diameter of 5.772 in., as shown in the lower left-hand corner of Fig. 1. Little trouble was experienced in securing a good surface upon which to work, and when finished, the surface checked within 0.0005 in. of being parallel. The whole collar was then turned for two fits, both of which were made for shrink fits about 0.005 in. smaller than the diameter of the shaft. This is shown in section *AB*, Fig. 1.

While machining the old thread from the shaft, a small groove was turned in the shaft (which is shown

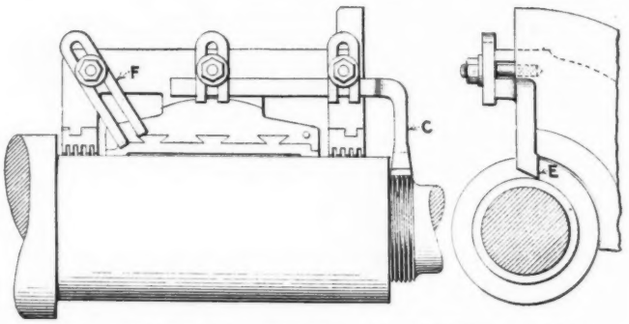


FIG. 2—SHAFT WAS TURNED DOWN WITH A TOOL CLAMPED TO THE BEARING PEDESTAL

in the section) to assist in holding the weld which was later used to fill in the space as shown. Considerable care was taken in machining the steel ring carrying the new thread, to insure that all surfaces be concentric. This was accomplished by boring the locknut, shown partly in dotted lines in the lower left-hand corner of Fig. 1, to the new thread about $\frac{1}{2}$ in. larger than the original thread of the nut and using this for a chuck to hold the steel collar after it had been threaded to fit it. The surfaces then coming in contact with the turbine shaft were finished, thus insuring a collar absolutely true with relation to the shaft and with relation to the thread. The collar was shrunk in place and, while cooling, held in contact with the end surfaces by means of a ring held in place by the small thread on the end of the turbine shaft. After cooling, the angular opening under the collar, as shown in section *AB*, was electrically welded, care being taken to fill up the groove in the shaft and thus provide a section that would have a direct shear against the shaft.

After the welding, another tool, similar to that used for removing the old thread, was clamped to the top bearing shell and the weld machined to the radius shown. To further strengthen the collar and provide additional shear, three dowel pins were drilled through the collar directly into the shaft at a depth slightly greater than the thickness of the pin. These were driven a short distance below the collar, and the top of the hole was welded to prevent their backing out, as shown in section *AA*. After completing this work it was found to be true, no effect of the electric welding having been noticed in the way of distortion of the shaft. In setting the thrust collar again in place of using the original pointed setscrew, a square dog-point screw was set in the shaft about $\frac{1}{4}$ in. to prevent a repetition of the collar backing off. Some little hesitancy was expressed in the shop as to the exact amount of clearance that should be provided to make a satisfactory fit on the thread after the collar had been shrunk in place. There was no way in which this amount of clearance could be estimated, but fortunately the judgment of the man making the fit was very good, and after being shrunk in place, the collar had expanded

sufficiently to make the nut a neat and tight fit to the thread.

Referring to the method of removing the old thread from the shaft, this was quite easily done by having forged in the smith's shop, an L-shaped tool, shown at *C*, Fig. 2. This tool was given enough offset to have the cutting edge *E* come slightly below the center line of the turbine shaft, when clamped to the bottom half of the bearing pedestal with a set of U-clamps as shown. It was, of course, necessary to make all adjustments for feeding the tool into the thread by hand, but this was easily accomplished without releasing the clamp bolts, by tapping the tool with the hammer as needed.

It was, of course, necessary to clamp in position the bottom shell of the bearing to prevent its moving while the shaft was being rotated. This was done by bolting on the clamp *F*, Fig. 2. The time occupied in removing this thread from the shaft was a very small part of that actually required to do the work.

The machine was put in service approximately twenty-four hours after the trouble occurred, has been in operation continuously since and shows no effect of any trouble or weakening of this collar. The repair was decidedly cheaper and consumed much less time than would have been the case had the builders' recommendation of returning the shaft to the shop for replacing been followed.

A. C. DANKS,
Cleveland, Ohio. The Ashmead-Danks Co.

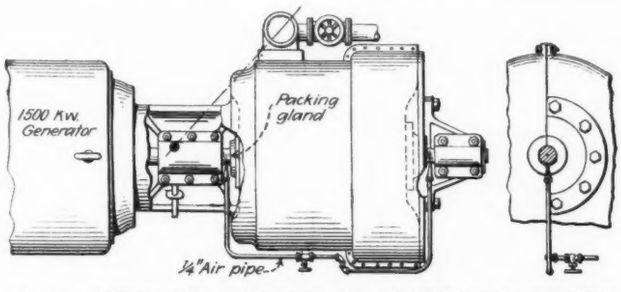
Eliminating Trouble from Water in Oil by Use of Air Jet

The method we have employed to overcome the trouble of water getting into the oil on our 1,800-kw. extraction-type turbine may be of interest to others.

The machine had been in operation only a few months when we began to have trouble from water in the oil, and in a short time it was necessary to change the oil about every two weeks. We tried new packing and also a shield, but could not stop water from getting into the oil.

One day while using compressed air to blow out some motors, the thought occurred that a jet of air between packing gland and bearing might overcome the trouble.

At the earliest opportunity we ran a line from the air receiver to the turbine and carried it to each bearing as shown in the illustration. The end of each branch was fitted with shower nozzles that had been taken off the paper machine. This has been very effective in overcoming the trouble. The turbine has operated for four months since putting on the air jets, and the oil has not been changed and is still in good condition.

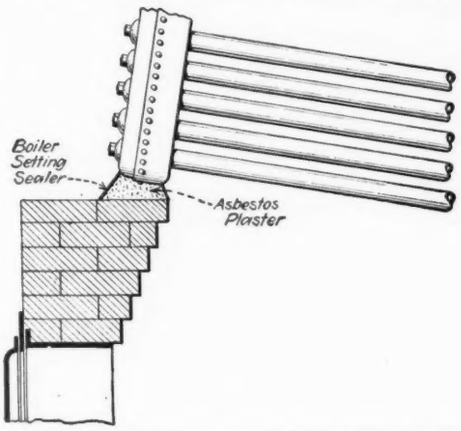


COMPRESSED AIR IS BLOWN ACROSS SHAFT BETWEEN BEARING AND PACKING GLAND

Fort Madison, Iowa. H. B. SEYMOUR.

Trouble with Brick Arches Under Headers

Constant trouble was experienced with the arches under the front headers of the horizontal water-tube boilers of an industrial plant to such an extent that they had to be rebuilt about twice a year. There was an overhang of about six inches from the top of the firing doors to the bottom of the headers, a distance of approximately fifteen inches, and the bricks were forced out and down by some force other than distortion due to heat.



SPACE BETWEEN BOILER HEADER AND ARCH WAS FILLED WITH ASBESTOS PLASTER

This trouble was eliminated by leaving a space between the top row of firebrick and the bottom of the header, instead of building the brick up to meet the header, as had been the previous practice. This space was filled with asbestos plaster, as shown in the illustration. Any expansion that took place in the header was taken care of by compressing the asbestos plaster and without throwing any pressure on the arch. This expansion joint permitted the arch to give continuous service for over a year without any evidence of weakness in the firebrick. The external surfaces of the plaster were made airtight by liberal application of an asbestos boiler sealer.

R. W. RIORDAN.
Brooklyn, N. Y.

He Missed His Guess

In the small city of Salisbury, Maryland, one evening in the early 90's while walking in the suburbs, I came to a roadway built on top of a dam used for storing water for a power plant to operate a flour mill. My attention was drawn to what appeared to be a small steam plant on the lower side of the dam. On examination it proved to consist of a portable steam boiler and an ordinary slide-valve center-crank engine of about 30 hp. belted to an 8-in centrifugal pump with piping apparently discharging into the millpond above the dam.

My curiosity was much aroused and I could not decipher the engineering problem. After making several inquiries, I was told that the mill owner, finding his power failing him through the long heated term during each summer, decided to put in a steam plant as a temporary booster, and made the attempt to pump the water from the tailrace back into the millpond, but of course his scheme was a failure. The natives explain that this engineer owner was a lawyer.

Brooklyn, N. Y. CHARLES WILSON.

Comments from Readers

Is the Current Leading or Lagging?

The article in the May 1 issue, "Some Notes on Power Factor," by L. W. Wyss, contains valuable data on an interesting and much neglected problem. I would like, however, to differ with Mr. Wyss on one point. In the fourth paragraph of his article he very correctly states: "The system power factor cannot be changed by any adjustments at generating plants." He then goes on to say: "In other words, given a system that supplies power at 80 per cent lagging, the generator will have to generate power at 80 per cent leading to overcome the lag, since for every unit of wattless current flowing through apparatus causing the lagging power factor, there must be a compensating unit produced by leading apparatus."

Now my conception of this matter has always been that a generator must generate current of the kind called for by the load, be it leading or lagging. In the foregoing case, where the system calls for power at 80 per cent lagging power factor, the generator supplying the load would have to operate at 80 per cent lagging.

Lagging current in the armature of a generator has a demagnetizing effect. Leading current has just the opposite effect. It is for this reason that the field of a generator is weakened by a lagging current and strengthened by a leading current. Now it is evident to anyone who has observed the operation of an alternating-current generator under load, that as the power factor decreases, the excitation must be increased to maintain the voltage, provided, of course, the load is inductive, as it usually is. This increased excitation does nothing more than counteract the demagnetizing effect of the armature current, which must therefore clearly be lagging. When two or more generators operate in parallel, it is the generator with the greater excitation that carries the lower power factor. This is borne out by the statement of Mr. Wyss to the effect that "a generator may be favored with power factor near unity by decreasing the field excitation, but care must be taken not to weaken the field so that there is danger of the generators pulling out of step, etc."

To state the matter in another way, we can raise the power factor of any generator on a system where two or more are operating, by decreasing the field excitation. This decrease in field excitation causes the other generators to carry more of the wattless current because their relative field excitation is now greater. Since a greater field excitation tends to counteract the effect of a lagging armature current, the current going through the generator under these conditions must be lagging.

In a similar manner it can be shown that on long high-tension transmission lines the electrostatic capacity at light loads calls for leading wattless current from the generators, and not lagging, as stated by Mr. Wyss.

FREDERICK KRUG.

Comerio Falls, Porto Rico.

What the Operating Engineer Wants

I have often wondered why it is that many contributors to power-plant journals do not make themselves more explicit in their statements and calculations. What the operating engineer wants are problems worked out in their simplest form, problems that he can understand and refer to when he needs information on that particular subject. To illustrate my point:

First, let us consider boiler ratings. Many of the younger operating engineers have a rather hazy idea about what this actually means. Suppose you had a boiler operating at 200 per cent of rating. This means that the boiler is producing 100 per cent more steam than it is rated to produce on the basis of a certain rule, which is that one square foot of heating surface will evaporate 3.45 lb. of water per hour from and at 212 deg. F. into steam at the same temperature. For every pound of water evaporated from and at 212 deg. F., 970.4 B.t.u. are required. In actual operation that temperature of the feed water is often less than 212 deg., and therefore the evaporation will be less than 3.45 lb. per sq.ft. If the feed-water temperature is 200 deg. F. and the boiler pressure is 170 lb., the heat content of the steam, above 32 deg., according to Marks & Davis steam tables, is 1,196.8 B.t.u. The heat in the feed water at 200 deg. F. is 200 — 32 = 168 B.t.u. The heat required to evaporate one pound of water at 200 deg. F. into steam at 170 lb. pressure is, then, 1,196.8 — 168 = 1,028.8 B.t.u. The ratio of the heat required to evaporate a pound of water into steam at 170 lb. pressure from 200 deg. feed water, to the heat required for water at 212 deg. is, then, 1,028.8 ÷ 970.4 = 1.06. In other words, the heat that will evaporate one pound of water at 200 deg. F. into steam at 170 lb. pressure, will evaporate 1.06 lb. from and at 212 deg. This figure (1.06) is the factor of evaporation. Now, dividing 3.45 by 1.06, we get 3.25, which is the rated evaporation per square foot per hour instead of 3.45 as under the standard condition. Now, say the boiler had 2,500 sq.ft. of heating surface, the evaporation would be 2,500 × 3.25 = 8,125 lb. If the boiler was evaporating 12,000 lb. an hour, the rating would be 12,000 ÷ 8,125 = 1.47 × 100 = 147 per cent, or 47 per cent above normal rating.

Second, suppose you have a steam-flow meter in the line to your engine and you suspect that it registers high, you can check it in the following manner: Say the meter registered 40,000 lb. of steam as the total consumption of the engine for a 10-hour period, also that the wattmeter registered 1,000 kw.-hr. for the same period. The pounds of steam per kilowatt-hour would then be 40,000 ÷ 1,000 = 40 lb. One kilowatt-hour is equivalent to 1.34 hp.-hr. The steam consumption per horsepower-hour will then be 40 ÷ 1.34 = 30 lb. Now if the guaranteed consumption of the engine is 17 lb. of steam per horsepower-hour and the meter indicates that 30 lb. is used, the flow meter reads 30 — 17 = 13 lb. high. Dividing 13 by 30, we get

0.434, or 43.4 per cent. In other words, the meter reads 43.4 per cent high and the true reading of the flow meter would then be 40,000 × (1.00 — 0.434) = 40,000 × 0 566 = 22,640 lb. instead of 40,000.

Third, it a meter of the displacement or V-notch type is used to measure the water passing through the heater to the boiler and you want to determine what percentage the meter reads high or low, first connect up barrels or measuring tanks graduated for a certain amount of water, between the meter and the feed pump in the usual manner and measure the water for a period of 10 or 12 hours. If at the end of the test you find by actual measurement that you have used 50,000 lb. while the meter registered only 35,000, this would be a difference of 50,000 — 35,000 = 15,000 lb. The percentage that the meter is slow is then $\frac{15,000}{50,000} \times 100 = 30$. If it were not possible to adjust the meter, the reading could be corrected by dividing the meter reading by $\frac{100 - 30}{100} = 0.70$. For example, if the meter reading equals 35,000, the amount delivered to the boilers would be $\frac{35,000}{0.70} = 50,000$ lb., or the same as found by measuring with the barrels or tanks.

Fourth, if your employer asked you what it cost to produce 1,000 lb. of steam in your plant, would you be able to give him the facts? Here is the way I figure it out.

$$\frac{\textit{Total plant cost}}{\textit{Total steam generated} \div 1,000} = \textit{cost}$$

Suppose the cost of operating your plant for one month was $1,500 and the total water evaporated, as indicated by the meter, was 3,500,000 lb. The cost per pound would be 0.0428c., and for 1,000 lb. it would be 1,000 × 0.0428 = 42.8 cents.

If you prefer to figure your costs in terms of kilowatt-hours proceed in the following manner:

Assuming that your engine consumed 600,000 lb. of steam for the month, as determined by flow-meter readings or other means, and the total kilowatt-hours generated for the month was 18,000, we would divide the amount of steam used by the total kilowatt-hours generated to get the steam consumption per kilowatt-hour. Multiplying the cost per pound of steam by the number of pounds used per kilowatt-hour will give the cost per kilowatt-hour. Using the figures given, we get 600,000 ÷ 18,000 = 33.3 lb. per kw-hr. The cost per pound of steam is 42.8 ÷ 1,000 = 0.0428. The cost for 33.3 lb. would be 33.3 × 0.0428 = 1.42 cents, the cost per kilowatt-hour.

Let me say in closing that when you run across any problems that look good, cut them out, because you never know when you may need to refer to them.

St. Bernard, Ohio. C. W. MOTTERN.

What Causes Tubes To Blister with Oil Burning?

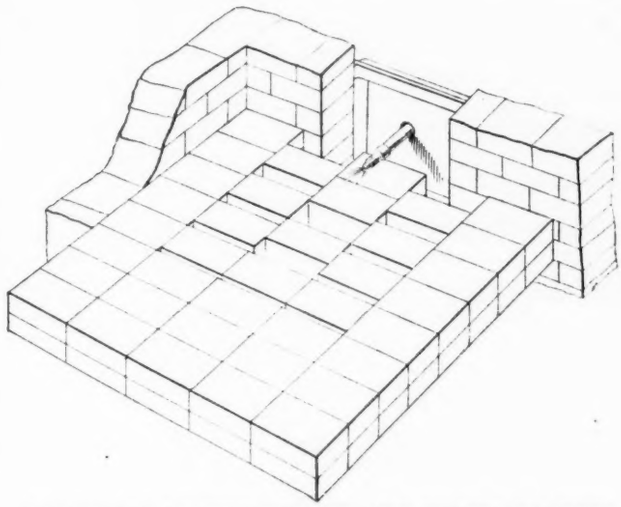
In a recent issue of *Power* C. W. Hill, of Hamilton, Ohio, told of his tube troubles. I have used oil for a number of years and, being interested, I gave it a great deal of thought.

In our plants we use both the inside and outside mixing types, and in some places one is better than the other. Since the furnace shown by Mr. Hill is only 8 ft. 6 in. long, in my opinion a burner that gives a short flame should be used. A long flame will strike the opposite furnace wall and be reflected to the tubes, producing a blowpipe action on both wall and tubes which would be likely to cause the trouble. It has been my experience that a short flame is more readily obtained by a burner of the inside-mixing type.

In our burners the mixture is carried through a 1-in. pipe, which may be of any length, and discharged through a slot in the tip to give a fan-shaped flame. The mixing in the pipe gives a soft flame several feet shorter than when the steam and oil come together inside the tip or just beyond it.

When oil burns with but little excess air, the furnace temperature is close to 3,000 deg. F. If the gases strike the tubes at this high temperature, damage will result.

The air should be admitted to the furnace through the ashpit door. The bricks underneath the burner



BRICKS BELOW THE BURNER ARE SPACED TO GIVE THE PROPER AMOUNT OF AIR

should be spaced to give the right amount of air to produce the best flame. In the illustration shown, the burner is about four inches above the firebrick, and in the block of 15 bricks three are left out and the bricks are then spaced as shown for the air to come through.

The oil pressure used by Mr. Hill seems to me to be quite high. We run it from 40 to 50 lb. in our plants.

I have operated burners with the oil pressure as high as 80 lb. occasionally, when forcing a boiler. It may be for this reason that Mr. Hill carries 110 lb. If we knew at what rating he operated the boiler, it would help considerably in suggesting a method of overcoming his trouble. ROY E. GRAVES.

San Jose, Calif.

With a short-circuit between the commutator bars the resistance of the contact is generally so high compared with that of the coil, that a large percentage of the energy transmitted through the closed circuit is expended in the defect. Consequently, in a large number of cases, before the coil is seriously injured conditions on the commutator will become so bad as to draw the attention of an attendant and the machine is shut down. If the coil has not been destroyed, the defect can usually be remedied by cleaning out the charred mica and filling the hole with mica and shellac or commutator filler compound, of which a number of varieties are on the market.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Steam Stop Valves for Boilers Set in Battery

When boilers are set in a battery, why is it necessary to provide each boiler with two steam stop valves? G. N. C.

When two or more boilers are connected with the same steam header, each boiler should be provided with two main steam stop valves and there should be an ample valved drain between the stop valves that may be opened to the atmosphere for relief of any steam that may leak through the outer stop valve when both main stop valves are closed, as when the boiler is out of use or undergoing internal inspection. Neglect of proper safeguards against the possibility of steam being blown back into the boilers under inspection has sometimes resulted in serious personal injuries, and most boiler insurance companies require connections of a character that will preclude accidents of this kind.

Formulas for Shafting

What is the rule or formula for determining the size of shaft required for the transmission of a stated number of horsepower? R. W.

The usual formula for commercial cold-rolled shafting for prime movers as head shafts carrying main driving pulley or gear, well supported by bearings, is

$$HP = d^3 R \div 100$$

in which HP is the number of horsepower to be transmitted; d is the diameter of the shaft in inches; and R is the number of revolutions per minute. For lineshafts, bearing 8 ft. apart, multiply by 1.4; for short countershafts multiply by 2; and for ordinary turned steel shafts take 0.8 of these values. The lateral deflection of a shaft should not exceed 0.01 in. per foot of length. For ordinary small shafting the distance between hangers is obtained by the formulas, $L = 7\sqrt[3]{d^2}$ for shafts without pulleys, and $L = 5\sqrt[3]{d^2}$, for shafts carrying pulleys, where L is the length in feet and d is the diameter of the shaft in inches.

Leakage of Steam-Control Valve on Pump and Receiver

In a plant where a pump and receiver are used for gathering the returns of a heating system, it is claimed that there is large loss of steam at night from unnecessary operation of the pump. Should not the control valve positively stop the pump when the receiver is nearly emptied of return water? D. B.

Most of the time the float-controlled steam valve is held nearly closed and wiredrawing of the steam cuts the valve seats, making it difficult to keep the valve absolutely tight. However, in most situations a fairly tight valve can be used with satisfaction by throttling the water discharge from the pump down to a point where the widest opening of the steam valve by the float will be a little more than sufficient for keeping the receiver clear of condensate, returned to it by the heating apparatus. Then, when the steam valve is closed by the float, a longer time will be required for a small steam leakage to build up high enough steam pressure in the pump to overcome the resistance of the throttled discharge. If the pump then works faster than necessary for keeping the receiver clear of water, the steam supply valve should be reground or reseated.

Relief of Girth Seams by Tubes and Through Stays

In horizontal return-tube boilers, what allowance is made for the reduction of area and assistance of the tubes, in reducing the stress on the girth joints of the boiler? R. F.

When one-half or more of the load that would act on an unstayed solid head of the same diameter as the shell is relieved by the effect of tubes or through stays, in good practice the strength of the circumferential joints in the shell is required to be not more than 35 per cent of the strength required for the longitudinal joints. As without allowance for head-to-head staying or reduction of cross-sectional area from presence of the tubes, the stress per unit of length of a girth seam would be one-half the stress of a longitudinal joint, this allowance for presence and holding power of tubes and through stays amounts to 30 per cent of the strength that would be required without such through staying.

Separation of Mercury in Stems of Thermometers

From loss of vacuum in our condenser, two of our thermometers became subjected to an unusually high temperature that caused separation of the mercury. These instruments are quite expensive and we would like to correct them if possible. We have tried shaking, jarring and various methods to make the columns continuous, but without success. What remedy is suggested? H. W. S.

Separation of the mercury was due to air or vapors boiling out of mercury when the thermometers were exposed to the unusually high temperatures. When properly made, the bulbs of the thermometers are heated to a high temperature for boiling out the air and the stems are sealed with the mercury overflowing. The separation after sealing commonly occurs in cheap thermometers and should not occur to high-grade instruments and, if purchased as such, the defective thermometers should be returned to the maker as they cannot be reconstructed with ordinary facilities of a power plant.

Cleaning and Polishing Switches and Contacts

How can brass switches and contacts be polished after turning green from exposure to ammonia gas? A. T.

When first formed, the corrosion can be removed by rubbing off the fixtures with a cloth moistened with gasoline; but deposits that have hardened have to be removed with emery cloth and afterwards polished with crocus cloth. After cleaning and polishing, further corrosion can be prevented by occasionally rubbing off the switches and contacts with an oil rag.

Fire in Coal Bin

Several times during the past two years we have been troubled with fire from spontaneous combustion in one of our coal bins. Analysis of the coal shows low volatile content. Prior to last year this had never occurred. The bin in question is 13 ft. wide, 40 ft. long and 17 ft. high and, when filled with coal, holds approximately 200 tons. Two ends and one side of this bin are brick walls; the other side is a 30-in. limestone wall with a rough protection of boards, leaving an air chamber 8 to 10 in. wide between the wall and the coal. We have driven a number of perforated iron pipes into the pile, but in spite of the air chamber and ventilating pipes we still have fires. What is suggested as the cause of the fires and what further action could be taken to avoid them in the future? J. J. I.

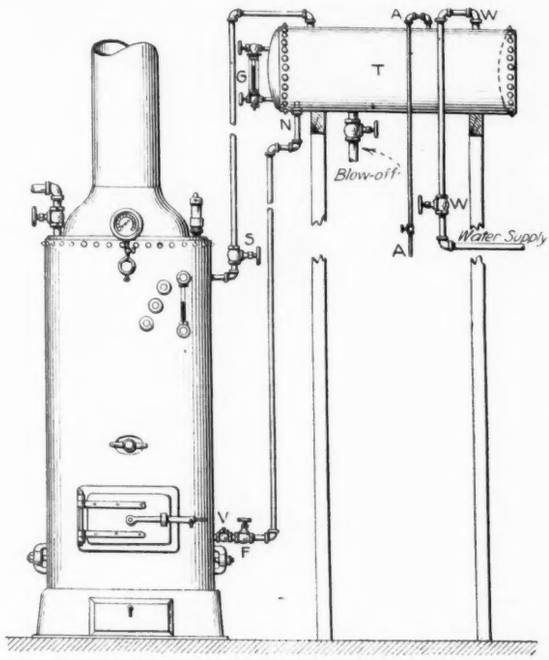
Oxidation of coal begins from the time it is mined and continues with access of the atmosphere. When the heat evolved is not absorbed with sufficient rapidity, the rate of oxidation increases. When not intentionally encouraged the chemical changes reach an intensity called "spontaneous" combustion. Hence absolutely blanketing out the air, as by "drowning" the coal under water, or keeping the coal cool, are the only methods of preventing "spontaneous" combustion. The heating mainly results from surface phenomenon and trouble usually originates in fine coal, because of the great extent of surface in proportion to the mass that must be heated. If coal finer than nut size can be kept out of the pile, the heating is so relatively small as to prevent development of rapid combustion and, as the rate of combustion depends on the temperature, coal stored at 80 deg. F. will "fire" much more rapidly than if put in storage at the temperature of 60 deg. F.

Greater trouble than formerly may have been due to receiving a larger proportion of fine coal or a reduction to finer sizes from rough handling. Eight or ten feet deep is the safe limit for obtaining sufficient cooling of most soft coals as ordinarily handled and rapid burning is more likely to be induced if the coal has become heated, as from exposure to the sun just before being deposited in the bin. It should be borne in mind that driving perforated pipes into the coal pile or other supposed methods of ventilation are beneficial only when a sufficient quantity of cool air is thereby circulated through the pile to discourage combustion; for otherwise artificial ventilation is likely to hasten the combustion. Once fire has made sufficient headway to be observable, the only recourse is to dig out and use the heated coal first, or tear down and spread out the pile, allow it to cool protected from the heat of the sun, replace it gradually by spreading it out over the whole bin; and if the coal is broken up fine, do not hinder natural ventilation of summer-stored coal by piling it to a greater depth than 6 to 8 ft.

Gravity Boiler Feeder

How is a tank or gravity feeder arranged for supplying a small upright boiler with feed water without using a pump or injector where the pressure of the water supply is less than the boiler pressure? R. E. L.

A general arrangement of a gravity boiler feeder is shown in the figure. A closed tank *T*, strong enough to safely resist the highest boiler pressure, is placed not less than five feet above the water line of the boiler and is alternately filled with water and discharged to the boiler through the boiler-feed check valve *V*. Filling the tank may be performed by pouring water through an open funnel and stop valve or by a valved



GENERAL ARRANGEMENT OF GRAVITY BOILER FEEDER

connection *W* with the water supply. There should be an air cock or valve connection *AA* for venting the tank when necessary for the operation of filling, and a glass gage *G* is convenient for indicating the depth of water in the tank. A long threaded nipple *N* in the bottom of the tank is connected with a feed stop valve *F* to the boiler check valve *V* and a steam outlet from the boiler with stop valve *S* is connected with a nipple *L* in the top of the tank. Then, for discharging water from the tank to the boiler, shut off the water supply *W*, close the air vent *A*, open steam valve *S* wide and regulate the rate of feeding by the stop valve *F*. Of course, for refilling the tank, the valves *F* and *S* must be closed and immediately afterward, to prevent collapse of the tank from condensation of steam in the tank, the vent *A* must be opened. For continuous operation it is advisable to have gravity filling tanks in duplicate, otherwise the running time for the boiler is limited to the tank capacity or alternation of tank filling and boiler feeding.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering

Interest and Depreciation

Suppose a salesman calls the engineer's attention to a new piece of apparatus which, it is claimed, will save a certain amount of fuel yearly. Suppose, also, that the engineer, on investigating similar installations elsewhere and working out the figures for his own plant, finds the claim to be substantially correct. He then goes to the owner, the purchasing agent or whoever holds the purse strings, and requests an appropriation for the purchase and installation of the equipment. In all probability he will be asked if it will pay. The mere statement that it will save a certain amount of fuel per year will not answer the question. Evidently, deductions must be made for all *additional* labor, rent, insurance, etc., required. In addition some kind of an allowance must be made for the cost of the apparatus. This is done in the items known as "interest and depreciation," which are of great practical importance.

The best way to understand interest and depreciation is to assume that no money is at hand for the purchase, but that it can be borrowed from a bank at a certain rate of interest. Suppose the rate of interest is 6 per cent and that the apparatus costs $1,000 installed and is estimated to have a useful life of 20 years, after which it must be thrown away. With no cash to start with, the plant borrows $1,000 and installs the apparatus. Each year the plant pays the bank $60 (6 per cent) as interest. If the apparatus never wore out or became obsolete, this interest charge would be the yearly cost of *owning* the equipment, since no initial investment of the plant's money was required, and the payment of $60 a year would enable the plant to keep the apparatus indefinitely.

If the plant does not borrow the money, but uses $1,000 of its own funds, the situation is fundamentally unchanged. This thousand dollars could have been invested elsewhere at 6 per cent, this opportunity being sacrificed as long as the money is tied up in the given equipment.

In addition to this interest on the money invested, some kind of allowance must be made for depreciation of the equipment. To take care of this, $50 (5 per cent of the cost) might be placed in a safe each year. At the end of 20 years the safe would contain $1,000, so that the old equipment could be junked and new purchased without borrowing any more money. The same thing would happen at the end of each 20-year period, or, if at such times it were desired to cease using the apparatus, the exact amount necessary to pay off the original debt would be on hand.

So it is evident that paying out $110 a year (5 + 6 = 11 per cent) the apparatus could be *owned* indefinitely. This shows clearly that the initial investment is equivalent to paying out 11 per cent of the cost yearly as long as the apparatus is used. This is called the investment charge and consists of 6 per cent interest and 5 per cent depreciation.

However, in arriving at the figure of 5 per cent we assumed that the owner did something that was not good business. He put away $50 each year (one twentieth of $1,000) in a *safe*. He should have *invested* a somewhat smaller sum each year at compound interest, the amount being so chosen that it would total

TRUE RATE OF DEPRECIATION, EXPRESSED AS A PERCENTAGE OF FIRST COST

Life, Years	Rate of Compound Interest				
	4	5	6	7	8
2	49.02	48.78	48.54	48.31	48.07
3	32.03	31.72	31.41	31.10	30.80
4	23.55	23.20	22.86	22.52	22.19
5	18.46	18.10	17.73	17.40	17.04
6	15.08	14.70	14.33	13.97	13.63
7	12.66	12.28	11.91	11.55	11.20
8	10.85	10.47	10.10	9.74	9.40
9	9.45	9.07	8.70	8.34	8.00
10	8.33	7.95	7.58	7.23	6.90
15	4.99	4.63	4.29	3.97	3.68
20	3.36	3.02	2.71	2.44	2.18
25	2.40	2.09	1.82	1.58	1.36
30	1.78	1.50	1.26	1.06	0.88

$1,000 in twenty years. If this fund could compound at 6 per cent, he would need to lay aside only $27.10 (2.71 per cent of the cost) each year. In twenty years, with compound interest, he would have $1,000.

This figure of 27.1 per cent is taken from the accompanying table, which gives the actual rate of depreciation, or percentage of the first cost to be invested yearly at compound interest to amount to the principal in a given number of years. It is immaterial whether a special fund is actually laid aside for depreciation, because when the apparatus is renewed the money used for the purpose will in any case come from funds that have been "working" in the plant elsewhere during the interval.

Suppose, now, that the apparatus will save $200 a year in fuel and that the additional expense due to labor, insurance, etc., amounts to $50 a year. We then may write:

Yearly fuel saving		$200
Yearly cost:		
Interest	$60	
Depreciation	$27	
Other	$50	
Total		$137
Net yearly saving		$ 63

Theoretically, if interest has been taken as part of the cost (as here) any net saving, however small, warrants the installation of the apparatus. Failure to do so usually means either that the owner distrusts his own estimate of the gross savings or useful life or that the rate of interest chosen is too small. If he can clear 10 per cent by investing the same money elsewhere in his plant, he might logically use that figure instead of 6 per cent.

Power Plants of the Amoskeag Mills*

By WALTER G. DIMAN
Superintendent of Power, Amoskeag Manufacturing Company

In a little over one hundred years this company has grown until it now has about 18,000 *employees, over* 760,000 *spindles, with* 24,000 *looms. It weaves about fifty-one miles of cloth an hour and requires about* 45,000 *horsepower.*

THE Amoskeag Manufacturing Co. at Manchester, N. H., controls all the textile manufacturing plants stretching along the east bank of the Merrimac River for nearly two miles, and spanning the river by its own bridge, controls the other mills occupying the slopes on the west bank. The mills have a floor space of approximately 168 acres and have probably grown to their limit in size, and any further development will be more along the line of centralization coupled with electric generation.

As late as 1880 the mills depended mostly on water power to operate the machinery, but for heating and minor purposes boilers were installed. At that time there were 15 boilers, each having 1,500 sq.ft. of heating surface. About 1883 it was thought advisable to concentrate the various boiler plants into one plant. In order to accomplsh this, a boiler house was erected on the west bank of the river and steam was distributed from this to the various places then being supplied from the smaller houses. In some cases steam was delivered through large pipes a distance of 1,700 ft. with very little drop in temperature. Most of the boilers and piping for this work were manufactured in the plant itself, and it should be a matter of pride to the men who did the work that it has proved so satisfactory through all the time it has been in operation. Sixty boilers are in this boiler house at the present time.

Beginning the Centralization of Power

In 1909 the first move was made toward the centralization of power. Upon final completion steam and power will be furnished to the entire Amoskeag Company from three main boiler houses, one at the south end of the plant containing 59 boilers, one in the west central part containing 60 boilers, and one in the north end containing 64 boilers all of 1,500 sq.ft. of heating surface. Later on, one of these plants will be remodeled into a modern station containing large water-tube boilers with up-to-date equipment. This will eliminate considerable labor as well as give us better operating economy due to higher pressures and temperatures.

All three of these boiler houses were originally designed for coal operation. Each boiler is fitted with an automatic underfeed stoker with forced-draft equipment, the stoker and forced-draft fan speed being controlled from the steam pressure. In connection with these stokers and the use of coal it might be pointed out that the regular dead plates formerly installed have been changed. We, like a good many others, obtained very poor grades of coal during the late war, some of which was soft coal, but the larger portion was hard coal, screenings and culm. Before burning it at all with any degree of success, it was necessary to do considerable experimenting. If the mixture was right it could be burned, but with our method of handling and receiving it, this was impossible. At times we were burning practically all hard-coal screenings. After several experiments were made, the dead plates were changed over into a form of pinhole grates in order to get a better diffusion of air. These dead plates have been left in this form, and we are of the opinion that even with soft coal better efficiency is obtained.

The 64 boilers in the north-division boiler house are arranged in one row and are equipped with economizers. Each boiler delivers its steam into a common header which is 20 in. in diameter at the turbine delivery end. This header is approximately 500 ft. in length having an expansion of about 14 in. It is carried in rolls placed on wall brackets. Formerly, one 20-in. line ran the entire length of this building with another 20-in. line paralleling this for about two-thirds the length. These were hung on chains supported from the overhead girders. One of these pipes developed a leak near the joint, and after making tests on several lengths it was found that specimens were brittle, the metal breaking like cast iron at the blow of a small hammer. After this investigation all the main piping both in the turbine and boiler rooms were replaced. Expansion joints in the line take up the expansion, and anchors are placed at various places to divide the expansion.

Boilers Equipped for Oil Burning

About two years ago it was decided to equip this boiler house, for oil burning. Various experiments were made with different burners and oil equipment, and it was finally decided to install mechanical atomization. Two steel storage tanks were erected on an island in the river, each having a capacity of 55,000 barrels. These were each surrounded by a separate dike, each dike having a capacity of 1½ times that of the tank. Pipe connections are made with flexible metallic hose to the tank cars, and the oil flows by gravity through a 10-in. line to the suction of a 1,000-gal. duplex-type steam-driven oil sludge pump. This discharges the oil to either main storage tank on the island, and 24 tank cars can be unloaded in a nine-hour day. The burner pumps discharge the oil through either of two 5-pass oil heaters, then through 20-mesh strainers into the burners at the boilers. The oil pressure at the burners averages about 200 lb. and the oil temperature from 200 to 250 deg. F. These burners are so arranged that a certain amount of oil can be bypassed and returned to the burner-pump suction, the amount depending on the boiler load carried. The burner piping is so arranged that the load can be varied on one, 8, 16, 32 or 64 boilers through the operation of one return valve. With this oil installation 14,000 kw. load can be carried easily on the turbines. Each burner tip was designed to give not over 450 lb. of oil at 225 lb. pressure and 250 deg. F. The idea of the oil installation was not to overload the boilers, but to carry about the maximum load that was carried when burning coal. With coal the boiler room had a complement of 61 men. Today with all the boilers operating 12 operate the plant, or a saving of 49 men. Very little trouble has been experienced with the oil installation from its design or operation. When running at a maximum load about 5,400 bbl. of oil per week is burned.

The 60 boilers in the central-division boiler house are arranged in batteries of four in the main house. There are 29 boilers on the west side of the house arranged in 7 batteries of 4 boilers each with one additional fitted with a Dutch oven which is used in burning refuse. There are 19 boilers on the east side of the main house, and in a wing at right angles to the main house are 12 boilers used mostly for supplying steam to a vertical cross-compound condensing engine. There are no economizers in connection with this plant. A great number of returns close to the boiler house are brought back as well as considerable exhaust steam used for feed-water heating. This gives a very good feed-water temperature. The returns at a further distance are carried to central points and here used in manufacturing process work.

There are 59 boilers in the south-division boiler house arranged in 5 batteries of 10 vertical boilers with one battery of 9. These boilers deliver steam into two 18-in. headers which furnish steam for manufacturing purposes. Twenty-two of the boilers are so arranged that they can furnish steam to the turbine headers for use in the two turbines at this plant. There are no economizers in con-

*Abstract from a paper presented at the New England State Association, N. A. S. E. convention, held in Manchester, N. H., July 12 to 14, 1923.

nection with these boilers. This boiler house is used mainly in connection with the woolen department, requiring considerable night work. An average of 225,000 lb. of steam per hour during the day is delivered, and approximately 1,100 tons of fuel per week is burned.

The First Steam Engine

The first engine was installed by this corporation about 1872. This unit consisted of a pair of 30x77-in. simple horizontal condensing engines rated at 1,000 hp. and driving a jackshaft through gearing from the main flywheel. This engine was used for general power and to relay the water power. Since that time 15 engines ranging in size from 150 to 4,000 hp. have been added. These have gradually given place to the electric drive until today there is in operation one 34x66x48 vertical cross-compound condensing engine rated at approximately 4,000 hp. at 120 r.p.m. This is direct connected to a 2,500-kw. generator which feeds into the general power system. Another 34x60x72 horizontal cross-compound condensing engine operates at times. Both of these engines are used only in case of low water. One pair of 38x48 simple non-condensing engines installed in 1889 operate during the working day. These are rated at 1,800 hp. at 78 r.p.m. They furnish exhaust steam at 15 lb. (gage) back pressure for general process and heating work in the central division. One horizontal cross-compound condensing engine is used at the present time in connection with the waterwheels, but is to be discontinued during the coming summer and replaced by an electric drive.

The First Steam Turbine

The first steam turbine was installed in 1907. It was a vertical machine operating condensing on steam at 160 lb. This turbine was rated at 1,500 kw., but has run continuously from 2,000 to 2,500 kw. and is used today only during low-water periods or for emergency causes. When the plant was erected in the north end of the yard in 1909, two 3,500-kw. horizontal steam turbines were installed. They were fitted with overload valves so that a maximum of 4,500 kw. on each could be generated. Each was connected to a barometric condenser taking its water from the dam, giving the condenser a small lift. Under these conditions no pumps of any kind are used for condensing purposes. About 1910 a 5,000-kw. horizontal turbine was added to this station, connected to a condenser of the same type and working under the same conditions. The maximum output at this station is about 14,000. About 1916 a 3,000-kw. condensing turbine was installed in the south station in order to boost the line and to help out at this end of the yard. The load on these various turbines varies with the stream flow. With these machines a total of 19,000 kw. can be developed. With the engines now in use a grand total of 32,000 steam horsepower is available, leaving about 13,000 water horsepower to be developed when the plant is running full.

Using Byproduct Steam

We believe that power can be developed in no cheaper way than by using byproduct steam for manufacturing purposes. In order to accomplish this, a 5,000-kw. straight non-condensing steam turbine has just been purchased to be installed about December. This is to be used at the south-division plant to furnish low-pressure exhaust steam in the worsted department. All manufacturing and heating steam is to be passed through this machine (about 165,000 lb. per hour) and then used at 25 lb. (gage) pressure instead of using high-pressure steam as is now done. This will relieve the present boilers as well as create considerable saving, due to the fact that this load will replace some of the load now furnished from the high-pressure condensing turbines. After this is completed and has operated a sufficient time to prove its value, the installation of such a machine in the central part of the plant is contemplated, where there is used about 160,000 lb. of steam per hour for manufacturing and heating purposes. This steam can be passed through a non-condensing turbine and approximately 4,000 kw. obtained. With these two machines operating together with the average hydraulic power, there would be obtained approximately 27,000 hp., leaving about 12,000 kw. to be developed by high-pressure turbines. As the flow of water was more or less, the steam power would vary accordingly. In connection with these non-condensing turbines it should be pointed out that the load on the machines will be entirely dependent on the exhaust-steam demand, the turbine throttle being regulated by the back pressure. With this non-condensing installation coupled with the new contemplated high-pressure boilers and the present hydro-electric plant, operation should be simple and economical.

All the generators now feed into the general electrical system, and the speed is regulated from the main steam generating plant. The total waterwheel horsepower that could be developed is about 18,000, the remaining power being obtained from steam generation. During the last ten years an average of about 140,000 tons of fuel per year has been burned, of which 50 per cent was used for power.

About three years ago it was deemed advisable to erect a more up-to-date hydro-electric plant and to centralize the water-power development, thus obtaining a higher efficiency with larger units and doing away with the great number of smaller waterwheels. The high price of fuel and the difficulty of obtaining it made it also desirable to obtain more power from the water. In the early part of 1919 work was started and was continued up to 1923, when two of the three 7,500-hp. waterwheel units were started. These wheels are to be run as much as possible, shutting down the old wheels along the canal as the water gets low to provide water for the more efficient wheels at the new plant. Most of the older wheels will continue to run when there is surplus water available.

The Mechanical Stoker and Modern Plant Efficiencies*

By Joseph G. Worker†

The principles underlying the combustion of coal in modern power stations are well known. We read and study a great deal about theoretical possibilities, we discuss these details before engineering societies, and most engineers are well agreed as to the requirements when we talk about the proper burning of coal under steam boilers. Do we continue this intensive study into the boiler rooms and work out the engineering possibilities to a definite conclusion?

Those whose duties take them into steam boiler plants throughout this country know that engineering thought is not carried to a conclusion and the job finished in a workable operating plan.

I have been impressed with the conditions that exist today in our power plants. We talk about 80 per cent boiler and stoker efficiency and really spend large sums of money and a great deal of time over the possibilities of obtaining this economy with one process of fuel burning or another, when what we are really obtaining in our power plants is from 15 to 20 per cent less than this figure.

The trouble seems to be that there is a lack of co-operation among those whose duty it is to co-ordinate these functions and make it possible for the final result to be sought and not lose sight of the ultimate end through an absorption of enthusiasm before the whole scheme or plan of boiler-room operation is worked out.

This paper has purposely been prepared as a plea for the establishment of a better practice in the methods of handling our boiler rooms. A higher standard must be attained in order that an operating record will be brought about more in conformity with the possibilities in the equipment installed.

The men responsible for this low economy in our boiler rooms are: First, The executives who do not unreservingly insist on the completion of an engineering plant; second, engineers who do not demand the completion of their recom-

*Presented before Ohio Electric Light Association, Cedar Point, Ohio, July 10-13, 1923.

†Assistant to the president, American Engineering Co., Philadelphia, Pa.

mendations; third, the operating department who do not complete the job as definitely and finally decided upon by the management.

It cannot be stated that anyone is more responsible than the other. It makes no difference whether or not the executive or engineering departments present a 75 per cent combined efficiency for the boiler-room—the installation can be reduced to 65 per cent efficiency by the methods of operation. In another case the executives and engineers may be at fault in not taking the operating problems into consideration and forcing through a plan that is entirely impractical from an operating standpoint.

There is no reason for doing exactly the same things we did years ago; still, boiler rooms are being operated today the same as they were fifteen years ago. When boiler-room equipment is purchased to give a certain economy, is that plan followed through until that economy is obtained? Very seldom, because the enthusiasm or inspiration that was alive in the beginning seems to slowly but surely die and the plant goes on operating according to the human domination and not according to its engineering possibilities.

A case is recalled where the contract had been closed for boilers, stokers and all boiler-room equipment. The boilers were to be set high, and all details were carefully worked out because the economy of this plant had to be as good as the best. Weeks of time by executives and engineers were taken to decide on the equipment and one or two per cent in economy was fought over because it meant so much when the plant was put in operation.

What happened when this plant finally went on the load? The engineers finished their job and left; their position was that "we have designed for you a real up-to-date plant and now it's up to you."

The operating department changed often in the course of time, and it was not long before the operation of the boiler room was "do the best you can," without any conception of what the original executives or engineers had in mind when the plant was designed. The trouble in this case was that the "follow through" was lacking and consequently the plant was, and still is, operating ten points below what it was designed for.

What is needed is an organization in our boiler rooms that will have for its object the translation of technical engineering into operating engineering. The time has not come when a power plant can be designed and the same methods of operation followed through in one locality and under one set of conditions as in another section of the country and another set of conditions.

Conditions are daily encountered that prevent the operation of a boiler plant in accordance with its original design, but why do we stop when these difficulties are encountered? Why do we not proceed and work hard to attain the final ultimate results?

Are we interested in the economy of a particular piece of boiler-room apparatus or are we interested in the economy of the entire process. The important part of this analysis is this: The matter must be sifted down and the causes of the difficulties determined and a sincere effort made to overcome the troubles. This sort of boiler-room organization costs money, but is not the return a good one when there are possibilities of increasing the economy five or ten points?

We hear considerable about "test performance" and none seems to care much whether "test performance" is obtained or not. The only good reason ever given for not obtaining "test performance" of a stoker, boiler or other apparatus, is because it means hard work and a high-character organization; but on the other hand, why not get this performance? If the operating departments were a little more rigid, they might find that the performances guaranteed are more easily obtained than they suspected.

Better practice could be obtained in our boiler rooms if more attention were given to the possibilities presented to the men involved. The writer knows of only one technical man who has stayed in the boiler-room operating work as a *career*. This man is not the kind who tells of all the efficiency equipment that is needed, etc., and why this should be done and how you should operate the equipment, etc. He can actually do the work and do it in a highly technical way.

The point I wish to bring out is that this phase of fuel burning should have just as much compensation possibilities as any other endeavor, and it should not be necessary for a man who has studied boiler-room problems and combustion to seek new fields and other positions.

Just at this time there is a considerable thought being given to our methods of burning coal under steam boilers. While we are troubling ourselves over one or two points economy between pulverizing coal and burning it on stokers, let us not overlook the five to ten points lying dormant in most operating plants today. What are the possibilities of spending some money in preparing the coal for the stokers? What are the possibilities of taking out the old stokers that were installed ten years ago and replacing them with a more highly developed equipment? Do not lose sight of the fact that better performance can be obtained from the present-day stoker compared with stokers made ten years ago. Even five years ago stokers were designed for an entirely different set of conditions from that now obtaining in most power plants.

All this means that we must give careful thought to our boiler-room problems. This cannot be done without skilled engineers who will spend the time in the boiler room and bring them up to a state of efficiency that is more nearly in line with what is possible. When we have that job done, then I am in accord with taking up the next step of design and engineering that will bring about better results.

Exterior Color Treatment of Transformer Cases

The problem involving the effects of various colors for transformer cases on internal temperatures is complicated by the fact that while light surfaces reflect heat to a greater extent than dark surfaces, at the same time the dark surfaces, in general, radiate heat from within at a higher rate.

A complete report on the effects of various colored cases on the oil temperature of distribution transformers by L. J. Moore and J. S. Moulton, covering tests conducted by the San Joaquin Light & Power Corporation during August and September of 1922, is summarized in the N.E.L.A. 1923 Electrical Apparatus Committee's report as follows:

Four 3-kva. distribution transformers were employed for the tests, mounted on pole structure outdoors and receiving the same exposure which they would in actual service. Tests were made as follows:

(a) Effect on the oil temperature of the transformers under no load and not excited which various colored paints applied to the exterior surfaces would have.

(b) Similar information as to oil temperatures when transformers were excited at normal voltage but with no other load on the windings.

(c) Similar information with windings subjected to full load.

(d) Inherent differences in oil temperature due to variations in construction eliminating any relative effects due to case color by painting the cases of all transformers black.

Transformers consisted of two well-known makes and were painted black, dark gray, Westinghouse standard gray and light gray, respectively.

Conclusions:

That gray paint will not reduce oil temperature more than 3 to 4 deg. F., or 1 to 2 deg. C. during extremely hot weather seems established. This, it is stated, was a disappointment in view of the seemingly prevalent belief that a much larger reduction for the lighter paint would be found.

The report goes on to state: We have reached the conclusion, after a very careful study of the results herein recorded, that any additional expenditure to procure a gray case in place of black would not be justified. This is in view of the fact that the differences in temperature do not under full-load conditions vary any more than the differences obtained from various makes operating under identical conditions. Assuming that gray or black tanks are available at equal cost and that experience shows that the gray paint stands up in service as satisfactorily as the black, we would be inclined to favor the medium gray tank. We feel very strongly, however, that any expenditure to repaint black cases now in service would not in any way be justified.

What Power Means to Civilization*

By F. R. LOW

WHEN in 1760 James Watt applied for a patent on his steam engine, he said:

"I have what every subject of Your Majesty desires—power."

Few who are enjoying its benefits today realize the part that power has played in the development of the past century or how completely the industrial and social condition of the world has become dependent upon it.

No other thing that man has accomplished has done so much to advance the human race and to give mankind the mastery over its environment, as the steam engine.

It is only thirteen years ago that we commemorated the centenary of the death of James Watt; and the broad fruition of his invention has come largely since he passed away.

True, there were forms of artificial power, even steam engines, before Watt's time. Savery and Newcomen had made steam-driven pumps, and it was in repairing a model of one of these at the University of Edinburgh, where he was employed as an instrument maker, that Watt, with his analytical mind, saw its defects and possibilities and started the train of development that has made it the most powerful servant that the race has ever had.

The first steam engine that ever ran in America was one of these Newcomen pumps, brought over in 1753, when Watt was in his teens, by Josiah Hornblower, and erected at Schuyler's Point in Newark Bay, to pump out a copper mine. The cylinder of this first American steam engine is in the National Museum at Washington now, and a most interesting pamphlet descriptive of the installation is published by the New Jersey Historical Society at Newark. The boiler was extant up to comparatively recently, but was destroyed as junk. What a relic this first American steam engine would have been if it could have been preserved in its entirety! Hornblower became a distinguished citizen of New Jersey, served in its legislature and was buried at Belleville in 1809, not much more than a century ago.

Can you visualize the conditions as to labor and intercourse and communication in those comparatively recent times? With the exception of the aid that he got from a few unimportant water powers, man had to win his subsistence and all the comforts and luxuries that he enjoyed by the exercise of his own muscles and those of the animals that he had domesticated. The radius of his existence was set by the distance to which his horse could carry him, and comparatively few saw more of the world than their own and the contiguous settlements.

Perhaps the best realization of what power means to civilization can be had by tracing its bearing upon the day's life of an individual.

He turns on his bath in the morning, and generally a great steam-driven pumping engine, of the existence of which he has probably never thought, sends the water gushing from the tap. He would probably shirk that bath if he had to draw it by pailfuls from a well.

The clothes that he puts on have been spun and woven in great steam-driven factories, and the family spinning wheels and craftsmen's looms of past generations are consigned to attics, museums and ancestral reliquaries.

The paper beside his plate has been made in a power-driven machine and printed upon a power press. The food that he eats has been planted and harvested by power-driven tractors, prepared by power-driven machinery, and brought to his table by power-driven transportation.

He takes a power-driven trolley or railroad, or ferry or auto to his place of business. A power-driven elevator lifts him to an upper story. Power-actuated devices have prepared and delivered to him the material upon which he labors, and power drives the machine which he perhaps operates. Even the executive is dependent upon power for the delivery of his mail, and for the current that operates his telegraph and telephone and phonograph.

And in his home, how many of the comforts and conveniences that he enjoys could he afford if they, had to be made by hand—rugs, carpets, hangings, dishes, pottery, cutlery, silverware, pictures, books, magazines, pianos, furniture, blankets, table and bed linen? The day's work of the average workman, thanks to power and mass production, will exchange for more of these than a king's fee would have purchased a few generations ago.

And when he turns the switch that puts out his light, on retiring, he severs the connection between his home and a great electric station that day and night is pumping power through a network of wires for all sorts of uses by all sorts of people.

Where would the confines of civilization upon this continent have been today if transportation had depended upon the waterway and the prairie schooner?

What would the skyline of New York have been without structural steel? Steel cannot be produced without power, and a three- or four-story city would be the limit without power-driven elevators.

How large would New York be and how many people could get to and from it and get about in it for their daily work if they had to walk or ride in horse-drawn vehicles?

A large city would starve in a few days if there were a sudden cessation of artificial power; even its stored perishable food supply depends upon power-produced cold storage for its preservation.

Recent winters have shown the possibilities of a breakdown in the operation of our power-operated fuel transportation system.

How many of the industries and businesses upon which my hearers are dependent for their salaries and wages would be possible of continuance if the power which operates them, or which furnishes their staples, were cut off? Can you think how completely the tenor of your own life would be changed if there were a 100 per cent effective strike of everybody and everything connected with the production of power?

Look about you at the myriads of things that are made of metal, the plumbing and lighting fixtures, the locks and hardware, the cutlery and tools, and domestic machinery of all sorts; think of all the power-driven tools, and the machinery in the factories by which these things are made. How many of these common-place things would be available if the mines had to be run, the ore converted and the metal worked into finished products by hand? A paper of pins would represent a day's labor, and we would be writing with quill pens.

Somebody has said that the measure of the civilization of a people is its use of paper—or is it soap? Never mind, either is true. Do you realize the tremendous effect upon man's development and condition of the copious literature, the ready diffusion and absorption of recorded thought and record of achievement of which recent generations have had the advantage? I leave with you to develop the thought of how much this cumulative development would have been stifled by hand-made paper and hand printing.

Without the use of power many of our common household supplies would be impossible in their present convenient form. Flour and meal and spices must be ground, sugar mills run, and all of those convenient breakfast foods and other things that come in handy little cartons are prepared in power-driven factories. The aluminum of which so much kitchen ware is made is a product of the electrical furnace, so is calcium carbide, upon which acetylene and the art of autogenous welding depend. Carborundum, chlorine, caustic soda and many of the materials of the arts and industries are producible in adequate quantities only by a generous use of power.

The electricity that has come within a comparatively few years to play so important a part in our lives is only a special form of power. At the source of every electrical distributing system is a great power station converting the

*From a radio talk delivered over WJZ, New York, Aug. 18, 1923.

latent energy of fuel, or falling water, into power in the electrical state, and it is the power of these engines and turbines that, transmitted electrically, operates your telegraph and telephone, your street cars and lights and motors. The light that floods your home at the pressing of a button is simply the reconverted sunshine absorbed by the vegetation of a forgotten age, buried and stored in the shifting crust of the forming earth, mined as coal, converted into mechanical power, and conveyed as electricity, to shine again at your demand. Without power we should be burning wood for fuel, tallow dips for light and riding in horse cars, even if without power we could fashion the rails and mechanism for these.

Without power the radio would be impossible. It takes no inconsiderable amount of power to operate the station by which this is being broadcasted.

Of course without power there would be no automobiles or aeroplanes, no railroads or steamships. Cities now separated by hours would be days and weeks apart, and Europe at the end of an uncertain wind-borne cruise. News and business intelligence would be limited in its dissemination to the speed of the mounted rider; the products of each locality would be condemned to use within carrying distance of the place of their growth or manufacture, and the economies of aggregation, big business and mass production be out of the question.

The wealth of a country, those things that are available for the supplying of the necessities and the gratification of the tastes and desires of a people, are dependent upon its ability to produce. In 1869, the first year that the United States Census Bureau regarded power statistics as of sufficient importance to be noted, there was available to each wage worker in the industries of the country 0.6 of a horsepower. The last census, that of 1919, showed that this had increased so that there was available in that year to each wage worker in our mills and factories on an average 3.25 horsepower. The significance of this powerful aid in reducing arduous muscular labor to the simple direction of a machine, in reducing the man-power required per unit of production and in the increased product made cheaply available to the people is obvious.

Perhaps I have said enough to set you to thinking of the leading part that power is playing in keeping up the living conditions of the average human being and advancing the comfort, happiness and well being of the race. The extensive and growing use of artificially produced power has brought us nearer to the goal of an assured, safe, comfortable and enjoyable existence for every inhabitant, in exchange for a reasonable amount of labor, than ever before in the history of the world. Deprivation of its advantages from any cause would seriously reduce the man-supporting capacity of our planet and reduce the survivors to a condition of slavish struggle for a much less satisfactory existence.

Safety Precautions with the Mercury Boiler

Apropos of the use of mercury boilers for improving power-plant efficiency, a recent issue of the *Travelers Standard*, a periodical devoted to the study of safety questions, discusses some of the safety problems that must be solved in connection with the use of mercury in power plants. The following is a brief abstract of the points brought out:

At first thought there are many decided and seemingly fatal objections to the use of mercury vapor for operating turbines, but these have all been considered, and a sincere attempt has been made to solve every difficulty in a rational way. It is said that the mercury turbine has already reached the stage at which it appears to be a commercial possibility. It may be that practical experience will develop difficulties not yet foreseen, but that possibility has to be faced by every new development. Certainly there are involved in connection with the mercury boiler hazards that are unfamiliar to engineers who have had experience only with steam.

One of the problems is to design the boiler so that evaporation will take place quietly and without "bumping," which, in view of the great density of mercury, would produce severe shocks and throw severe stresses upon the material of the boiler. Furthermore, the temperature at which the evaporation of the mercury takes place is far higher than that of the present ordinary steam boiler, and a corresponding allowance must be made for the expansion and contraction of the parts. These points have been carefully considered in the experimental plant now going up at Hartford.

As far as pressure is concerned, there is little difficulty, because the maximum pressure of the mercury vapor will be only about 35 lb. per inch gage. Some engineers feared that the mercury would enter into combination with the steel and thereby gradually destroy it, but there does not appear to be any likelihood of such action under the working conditions that actually prevail.

One of the most important of the new problems that arise in connection with the use of mercury for power generation, is the prevention of leakage. The entire apparatus must be as nearly leak-proof as possible, mainly on account of the poisonous character of mercury vapor, but also because leakage would be costly. This point has been given careful attention, and several very ingenious devices have been involved that insure the practical absence of leakage.

Except for the revolving shaft where the turbine runs out through the casing, all joints at which leakage might occur are tightly closed by welding. Even where riveted joints are used, a type of construction is adopted that allows oxyacetylene welding in addition. Units that must be taken apart from time to time are also welded, and when it is necessary to open them up the metal used to make the joints tight is removed by means of an air-driven chisel. The entire apparatus is so effectively inclosed that it has been likened to a can of sardines the contents of which cannot be reached without a can opener. As a further precaution most of the parts from which leakage might occur are placed inside of inclosures connected to a ventilating stack.

When leakage does occur, it may be detected by the presence of tiny droplets of condensed mercury, provided it takes place in some visible part of the apparatus. If, however, the leakage occurs under a protective covering (such as heat insulation) there is danger that a significant amount of it may collect outside the apparatus and that the workmen may be exposed in this way to the danger of slight chronic mercury poisoning, especially if the mercury escapes from some point that is hot enough to make a fairly rapid evaporation probable.

We do not mean to imply that there is danger of acute and severe poisoning under such circumstances, because the quantity of mercury vapor present in the air of the power house would not be greater than that which would arise by evaporation of an open pool of mercury exposed to the temperature of the room. Yet the possibility of chronic poisoning through the continued inhalation of small quantities of mercury vapor should be carefully considered, and the men who work about the place should be watched to detect any symptoms of this poisoning at an early stage. In our judgment the floor of a room in which mercury is extensively used, should be as smooth as possible and free from any irregularities in which mercury can collect. The corners where the floor joins the side walls or where the columns or machine supports rest upon it should be smoothly rounded to a radius of one or two inches, so that the floor can be thoroughly cleaned. Free ventilation is also important, this, however, presenting no particular difficulty in a boiler room because of the large quantities of air that must enter to supply the oxygen needed for combustion.

Men who have been exposed to mercury vapor in any way should wash themselves thoroughly with sulphur soap to remove particles of mercury that may adhere to the skin. Their work clothing should also be entirely removed and washed with sulphur soap for a like reason.

On the whole we are inclined to believe that the mercury boiler can be made to compare quite favorably with the ordinary steam boiler as far as safety is concerned, provided proper precautions are taken.

News in the Field of Power

United States Coal Commission Shows Who Profiteered

First Official Announcement Concerning Pyramiding Coal Profits

THE United States Coal Commission believes it opportune to make public more details on the subject of pyramiding middlemen's profits, described in the July 5 report by only a single paragraph.

The Commission's inquiry regarding the source of high-priced anthracite sold during the winter of 1922-23 leads to the conclusion that the speculative jobber or wholesaler was a prime cause of the extremely high premiums paid for anthracite during the recent shortage in New England, as well as in other parts of the country.

Under normal conditions wholesalers have a proper place in the distribution of coal. They furnish an outlet for the coal of small mines whose total tonnage is too small to warrant the maintenance of a selling organization. In times of normal market, competition among wholesalers for the operators' available tonnage on the one hand and for the consumers' and retailers' trade on the other keeps margins and prices low and commensurate with the services rendered as distributors of coal. In time of a panic or seller's market, however, the independent wholesalers tend to become speculators, and buy and sell among themselves, thereby pyramiding margins and advancing prices without rendering any equivalent service in bringing the coal nearer to the consumer.

Blames Interlocking Directorates

The wholesalers whose activities resulted in premium prices last winter are, nominally at least, not directly connected with the mines producing the coal, although there are a considerable number of cases in which operators and wholesalers, while separate and distinct corporations, are related through interlocking stock ownerships, interlocking directorates and interlocking officers. In some cases the inter-relations extend to a chain of operators and wholesalers. In times of seller's market anthracite is passed from one to another of these closely related interests, each taking a profit on the transaction, with the result that wholesale margins are pyramided and the consumer pays extremely high prices and profits to a group of related interests. In other cases the pyramiding results from speculative buying and selling among wholesalers who are separate and independent. Many cases of pyramiding of margins, both by related interests and among really separate and independent wholesalers, have been traced by the Commission.

Anthracite coal especially yields itself to speculation among wholesalers whenever there is an interruption of production due to strikes, railroad disability, or any other cause. In tracing carloads of high-premium anthracite coal purchased by New England retailers last winter, it was found that as many as four wholesale purchases and sales sometimes intervened between the mine and the retailer. More than half of the 750 cars of anthracite coal of domestic sizes traced passed through the hands of only one wholesaler at margins varying from 20 cents to $3 per gross ton. Margins frequently taken were 50 cents, 75 cents, $1.25, $1.75 and $2.50 per gross ton, the majority of margins being between 50 cents and $1.25 per ton.

A considerable proportion of the cars traced, however, went through the hands of two wholesalers at margins varying from 25 cents to $4.75 per ton. In the case of the carload on which $4.75 was taken the first wholesaler took 50 cents and the second $4.25 per gross ton.

On a small number of cars passing through the hands of four jobbers, the total margins taken on individual cars ranged from $1 to $2.25 per gross ton. On the car for which margins amounted to $2.25 per ton, the first wholesaler took 25 cents, the second 40 cents, the third 35 cents and the fourth $1.25 per ton.

Some mining companies were found to have had special arrangements with wholesalers by which the mine billed the coal to the wholesaler at the prices approved by the Pennsylvania Fair Practices Committee with the understanding that if the wholesaler sold the coal at a price above the mine price billed plus a stipulated wholesale margin or commission, the wholesaler remitted the balance to the operator. Other mining companies sold coal to individuals, in some cases their own officers, at prices agreed upon with the Fair Practices Committee. These individuals then sold the coal to other wholesalers at higher prices. Such practices applied especially to shipments to destinations outside the State of Pennsylvania, thus indicating the ineffectiveness of state regulation of prices at the mine over coal entering into interstate commerce.

Governors Will Co-operate With Federal Fuel Distributor

Federal Fuel Distributor Francis R. Wadleigh met with the governors and other representatives of the anthracite consuming states at a conference in New York, Tuesday morning, August 28, for the purpose of discussing plans for handling the fuel situation in the event of a strike on Sept. 1. In addition to the state officials there were present representatives from the railroads, coal associations, and the Interstate Commerce Commission.

Only two plans were submitted, one by Mr. Wadleigh which, in fact, was not a definite plan at all but a general suggestion involving the co-operation of all concerned. The other plan, more definite in scope, was outlined by Mr. Brydon, president of the National Coal Association. Upon objection of the representative from Maryland, however, Mr. Brydon's plan was voted down and the meeting adjourned with a rather perfunctory resolution promising to co-operate with any plan that the federal fuel authorities might evolve.

The principal suggestions offered by Mr. Wadleigh were that "the Federal Government proposes to keep in close contact with the state organizations, as well as with the railways and the sources of supply, and will do all in its power to assist the states in securing the needed supplies of fuel. It is recommended that each state and municipality should have, as a part of its fuel organization, traveling instructors, whose duties should be to visit the various localities, keeping in touch with the coal dealers, acting also as connecting links between the consumer and the state or local authorities. In this work the United States Bureau of Mines and the Federated American Engineering Societies will assist."

Mr. Brydon's plan, which was contingent upon the government proclaiming an emergency and fixing prices for coal, was to make use of existing channels to the greatest extent and merely facilitate distribution within the industry itself through the establishment of an emergency organization. This emergency organization would place a representative in each anthracite-consuming state, who would act in conjunction with the representatives of the state authorities and of consumers, retailers

and wholesalers. Each such representative of the emergency organization would give information as to kinds and supplies of bituminous coal available, and would receive orders and place them in the various producing fields at the price fixed by the government. In each of these producing fields there would be a representative of the emergency organization familiar with local conditions and able to place the order with a producing company in such a way as to secure prompt and satisfactory delivery.

However, under existing laws no emergency organization of the operators can itself undertake to agree on or fix prices for the purpose of keeping prices down in the absence of governmental co-operation. Therefore, until the government may deem the emergency such as to justify it in fixing prices by the method used during the strike of 1922, or otherwise, or will give its sanction to some other method, it would be impossible for any emergency organization of operators itself to receive and place orders for the purchase of coal.

The conference developed that there is now in storage, in consumers' bins or dealers' yards about 25 million tons, over 30 per cent of the winter requirements. The use of substitutes to make up the deficit, in case of a strike, was discussed, and it was brought out that the chief difficulty with bituminous lay not in its use in furnaces, but with the tenement-house trade where it is wholly unsuited for burning in stoves.

Pinchot Launches Giant Power Survey

Morris Llewellyn Cooke, Consulting Engineer, To Be Director of Survey

PENNSYLVANIA'S Giant Power Survey was launched Aug. 29, at the first meeting of the Board provided for by an act of the recent Legislature to conduct an outline survey of the energy resources of the state and the best methods for their utilization. Morris Llewellyn Cooke, a consulting engineer of Philadelphia, was put in executive charge of the survey as director.

Governor Pinchot, who presided, called attention to the probable far-reaching effect of giant power on the coal industry. Employment will be stabilized owing to the development of giant power stations at the mines. Economies will be effected through the recovery of the byproducts now wasted in burning raw coal. A greatly increased demand for coal will result from the larger use of power not only because of its wider distribution to farms, factories and homes, but on account of the more generous use of power resulting from lower rates made possible by production conducted on the largest possible scale, and because of the elimination of waste.

The Governor feels that his plans for giant power and the effort now being made by his Administration to straighten out the acute situation in the anthracite field are all of a piece. Governor Pinchot said:

> For weeks and months after our entry into the Great War, the effectiveness which we ultimately developed was held in check, by, what someone has called the distance disease—the battle-front was three thousand miles away instead of at the far end of a telephone wire. Principally because our utilities, even the largest and most far reaching of them, have grown up out of small and isolated beginnings, we have been slow to recognize that distance is a rapidly disappearing factor in public-utility development. In high-tension transmission of electric current and high-pressure transmission of gas, distance is an unimportant and state lines as meaningless as in the pumping of oil from the Oklahoma fields to the Atlantic seaboard. Giant power now seeks a new form of co-operation among these vast enterprises in which the distance factor will be accorded only the importance which modern science and modern engineering gives to it.

It was reported at the meeting of the Board that the state authorities had already received inquiries from a number of other states seeking information about Pennsylvania's plans for power developments and offering co-operation. In this connection Governor Pinchot recalled that the giant power act empowered the Board "to keep in view the mutual interest of this commonwealth and other states and to outline plans for the interchange of electrical energy with all other States within the practicable transmission distance."

No definite plans have been made for the conduct of the survey. But Governor Pinchot said in this connection:

> One point of departure from the usual in such investigations lies in the fact that our first concern will be with the small user—particularly with the farmer. No system of electrical development would be technically sound if not built on estimates of the industrial power load. Just so no system can be considered socially sound which ignores the more or less immediate requirements of upward of 200,000 farmers and perhaps as many urban and semi-urban householders in Pensylvania now without current.

The Giant Power Survey Board consists of the Governor, the Attorney General, the Secretary of Forests and Waters, the Chairman of the Public Service Commission, the Secretary of Agriculture, the Secretary of Labor and Industry, the State Geologist, a Deputy Attorney General and an engineer. Deputy Attorney General Philip P. Wells and Robert H. Fernald, Director, Department of Mechanical Engineering at the University of Pennsylvania, have been designated by the Governor to these two latter places.

Why Did Secretary Work Fire Arthur Davis?

In a special report from Washington, D. C., to the *New York Times*, under date of Aug. 27, it is stated that William Dudley Foulke, president of the National Civil Service Reform League, has written to Secretary Work asking questions regarding the dismissal of Arthur Powell Davis as Director of the Reclamation Service and the appointment of D. W. Davis, which is said to be contrary to civil-service law.

Mr. Foulke questions the authority of the Secretary of the Interior to abolish an office in the classified civil service and to appoint to the same office, with a mere change of title, a man without civil-service status. The controversy over the dismissal of Arthur Powell Davis, which has agitated not only civil-service advocates, but thousands of technical men, will be the subject of investigation by the next Congress.

After going into the qualifications of Mr. Davis, the politician, as contrasted with those of Mr. Davis, the engineer, Mr. Foulke asks:

> Can you wonder that to many it seems that your statement of Aug. 15 that the problems of water users could be "best handled by a practical business man," alludes rather to the business of politics than to any other business, and that there is a fear that the public interest will be sacrificed to the demand for men useful to the party, not only among the farmers and water users, but also in the next convention and campaign?
>
> Was Mr. Davis's resignation voluntary or requested? Was he not informed by you on June 16 that you had decided to give his place to another man, and did you not then request him to send in his resignation to take effect June 30?
>
> Did he not, accordingly, write you that in pursuance of your suggestion he so tendered his resignation, and did you not thereupon object to his statement that the resignation had been requested and say that you would prefer that it should appear that it had been initiated by himself and that surely he would not desire to advertise the fact that he had been "fired"; and did he not answer that he desired the world to know the facts, whatever they were? Did he not afterward write you that he had reconsidered his decision to eliminate those words, concluding that he would thereby be making himself party to a public deception?
>
> If your reasons for his removal were wholly for the interest of the service and were not political, why did you wish thus to deceive the public?
>
> You say that no diminished construction program is anticipated, but rather an increased and accelerated construction, and that the same chief engineer now is at the head of the work. But if these vast projects are still before you, ought they not still to be under the direction of the experienced man who had begun them—a man who was then offered and is now earning in private employment far greater compensation than that received from a Government which he was patriotically serving to his own pecuniary loss?

You say you offered him an appointment as consulting engineer. Was not this offer made on condition that he would omit the statement that his resignation as director was requested? And did you not warn him of the consequences to himself if he refused to omit that statement? Why did you do this? Did he not request of you a written statement of the reasons for his removal, and did you not answer that he was not entitled to such a statement under the law?

If you were looking for business qualifications, did you appoint a man who had been successful in business? Was the bank of which Governor Davis was the organizer and president markedly successful? Was it not rather to politics that his principal activities have been devoted? Had he not been a candidate for other appointments?

Among the Oil Engine Builders

A Brief Statement of the Condition of the Oil Engine Industry

IN CONTRAST to the lack of activity in many machine-building lines, oil-engine builders with few exceptions have their plants running to full capacity. Deliveries are as a consequence, somewhat longer than usual.

Orders for oil pipe-line pumping engines have served to absorb a considerable portion of the output of three Diesel builders and the last of the Sinclair Pipe-Line engines are being shipped, leaving only isolated pipe-line orders to be filled. Central stations, both municipally and corporately owned, are coming to appreciate the advantages of the Diesel engines over other forms of power. As a consequence this is a field that is covered closely by all engine builders, and a considerable percentage of orders received this year are from such plants.

There is a strong current toward the employment of the oil engine for operation in hydro-electric plants during breakdowns and during periods of low water which is encountered in the Northern States in winter months, and during the summer in the South. As an example of such a situation, the Peninsular Power Co. has purchased two 1,250-hp., two-stroke-cycle Diesels, each direct-connected to 1,075-kva. 6,600-volt alternators for installation at Iron River, Mich., where there is at present a 3,500-kva. steam-turbine plant in connection with the hydro-electric plant. Investigation showed that the fuel cost of the Diesels would not exceed one-half that of the steam plant. The plan of operation contemplates the starting of the oil engines as the river flow decreases, and the steam plant will be used only in the event that the decrease in flow is such that the oil engines cannot carry the load. The 2,150-kva. Diesel plant, including certain new ash- and coal-handling equipment for the steam plant, will cost approximately $200,000, or less than $100 per kva.

So advantageous is the oil engine that one hydro-electric company is seriously contemplating the installation of a 20,000-kva. Diesel plant. In view of the ability of builders to construct engines up to 6,000 hp. there is every reason to expect this plant to be the forerunner of several similar ones.

Flour mills have, during the year placed a number of orders, one engine builder having sold two 750-hp. Diesels to a Kansas mill, while another has sold three units that have gone into milling plants in the State of Texas.

The East, conceded to be conservative in regard to prime movers, as with other affairs, has during the year ordered a number of engines, ranging from 300 to 750 hp. in capacity.

The United States Government has on order a considerable number of units ranging from 2,500-hp. submarine engines to 60-hp. units for the Coast Defense Service. In addition several government barges have been and are being built with Diesel drive.

In the marine field the most notable features are the two 1,750-hp. Werkspoor Diesels built and installed in motorships by the New York Shipbuilding Corp., and the 3,000-hp. opposed-piston solid-injection marine engines built by the Sun Shipbuilding and Dry Dock Co.

Orders on file with all the builders together with engines shipped and in process of manufacture indicate that the Diesel engine is being purchased in larger powers than formerly. In the large sizes a Diesel plant can be purchased at a price under that of a modern steam plant; the operating costs are considerably lower. Diesel sales up to Aug. 1 approach the total sales of 1922.

The Diesel builders realize the disadvantage of high first costs by which the units of 300 hp. and lower are burdened. In consequence, almost without exception Diesel builders are experimenting with solid-injection engines for powers under 300 hp., expecting the Diesel of the future to be built in large units rather than below 300 hp. At least one builder even now, is willing to build 6,000-hp. units, and a number are ready to offer 3,000 to 4,300 units of a fairly standardized type.

One interesting development is the construction of small high-speed air-injection Diesel; one company has built a number of units to operate at 500 r.p.m., and a second manufacturer has obtained the American rights to an Austrian high-speed air-injection Diesel and will shortly be prepared to offer engines from 50 to 300 hp. This will be especially adaptable to such industrial uses as locomotive cranes, trucks, centrifugal pumps, etc.

The semi-Diesel engine builders have been able to obtain all the business that the plant capacities could handle. One builder is turning out approximately 1,300 hp. per week at present, and the average for the year has been at least 1,200 hp. Several concerns are building from 200 to 500 hp. per week, the total output of semi-Diesels being at present close to 2,500 hp. weekly, or at the rate of 150,000 hp. per year. These engines are going into a variety of industries, cotton gins, irrigation, flour mills, small central stations.

For irrigation work the semi-Diesel has proved quite popular. In certain districts, as example, the rice district of Arkansas, central-station service was formerly used. The banker who financed the rice farmer found that the power bills were absorbing the farmer's cash, leaving him little to be credited against his bank loans. As a solution the banks have insisted on the farmer installing his own power, reducing irrigation costs by 75 per cent.

Cotton ginning has always been a fertile field for semi-Diesel sales. This year orders, which must be shipped before Aug. 1 to meet this year's cotton ginning demand, have so filled certain shops that other business has been neglected.

Raw-water ice plants have installed many of these engines, and a total operating cost per ton of ice delivered at the ice dock of under $1.00 is the rule rather than the exception.

A gradual increase in the compression pressure of these engines is going on. Starting at 120 lb. a few years ago, many builders have developed the engine until compressions of 250 to 300 lb. are common. In this way the low-pressure engine is being developed into a machine with compression pressures high enough to cause self-ignition of the fuel.

The consensus of opinion among engine builders is that the semi-Diesel will not exceed 300 hp. in capacity for some time to come. This capacity is apparently the rating above which the better economies of the solid-injection and Diesel engines preclude the use of the semi-Diesel.

Coal-Storage Possibilities Studied by the F. A. E. S.

On August 27 and 28 the Storage of Coal Committee of the Federated American Engineering Societies met in Chicago in the offices of its chairman, W. L. Abbott, chief engineer of the Commonwealth Edison Co., to consolidate the preliminary work for the preparation of the final report to the Federal Coal Commission. Before the issuance of the report the committee will have another meeting at Washington. Expectations are that the report will be ready about Dec. 1, and released for publication about Feb. 1.

For almost a year the committee has been gathering data on the subject of storage. It has had the co-operation of some 400 engineers in nearly every state of the Union, as well as operators, rail heads and distributors, so that it has amassed a wealth of facts from the producing, distributing, marketing and consuming angles of the coal-storage problem.

The committee realized that the

solution of the problem relative to the location of the coal in peak periods of industrial consumption was in its storage. This storage should be made during the summer, when coal can be mined and distributed easily by the railroad and water carriers. On the other hand, the producers, operators and distributors have argued for years that disintegration, spontaneous combustion and lack of storage space obviate the possibilities of storage.

Of the various experts participating in the committee meeting, Dean S. W. Parr of the University of Illinois, showed that a very small percentage of heat is lost in the storage of coal, his statement being based upon twelve years of experience with coal storage at Urbana. In his opinion coal storage is not so much a matter of finding space as of educating those who store it in proper methods of handling it. Even the most volatile of central Illinois bituminous coal can be stored with but little loss, if stored properly.

O. P. Hood, chief engineer of the United States Bureau of Mines, told of methods in dock and pier storage other than what is known as head-of-the-lake storage, but including all federal government storage with specific reference to the Army and Navy and the Panama Canal.

W. H. Hoyt, chief engineer of the Duluth, Missabe & Western Railway, presented an elaborate report on Duluth and Superior storage where the greatest and most efficient storage plants in the world are located and where during the last coal year 12 million tons of bituminous coal and approximately 1½ million tons of anthracite were stored. From the principles used there the committee is evolving many of its prime recommendations for presentation to the United States Coal Commission and American industry.

As a special example of lessons that may be learned from the head-of-the-lakes region, it was pointed out that New England might use advantageously the same methods of storing, seasonal conditions there being similar excepting that the lakes become impassable during the winter, whereas the New England territory is only seriously handicapped by transportation during the same winter months.

The committee has progressed far enough in its study to recognize that municipal, state and federal institutions are the worst offenders against the engineers' plan for storage. They are favored by priority orders when necessity arises and therefore seldom provide stocks of coal to carry themselves through emergencies. Even after the scramble for coal has reached the proportions of a panic, these institutions are found to be making an unreasonable and unjustified drain on the coal supply.

Dean P. F. Walker of the University of Kansas had just completed a trip, in which he had visited approximately fifty of the principal industrial centers in the United States, where he found conditions widely different, so that individual study and individual processes for the solution of their problems seemed essential. As a result of the trip and after conferences with the leading men in industry, he suggested an extended study of the possibilities for the establishment of large coke plants in industrial centers. This would at once supply cheaper gas to the community and produce a coke which is now urged as a substitute because of the threatened anthracite strike. This plan would not only eliminate waste but also facilitate storage, because when coal has been coked it may be stored readily, as there is no danger from spontaneous combustion. Such a plan would be of greatest value to the small consumer and especially the domestic consumer.

Other reports were: W. J. Jenkins, vice-president of the Consolidated Coal Co., of St. Louis, "Mine Storage Location"; D. M. Myers, consulting engineer, New York, "Economical Use of Stored Coal"; E. S. Nethercut, secretary of the Western Society of Engineers, of Chicago, "Development of Storage Possibilities in Chicago"; R. V. Norris, consulting engineer, Wilkesbarre, Pa., "Anthracite Storage"; Roy V. Wright, editor of *Railway Age Gazette*, "Items of Transportation."

L. W. Wallace, executive secretary of the F. A. E. S., came to Chicago especially to review the work of this committee. He announced that the report would rival in importance to American industry the "Waste in Industry" and the "Twelve-Hour Shift" reports sponsored respectively by Mr. Hoover and the late President Harding.

N. A. S. E. National Convention Program

THE outstanding features of the National Convention of the N. A. S. E. are as follows: Sunday and Monday, Sept. 9-10—Annual Conventions of the New York State and Pennsylvania State Associations. Monday, Sept. 10—Official registration of officers, delegates, visitors and exhibitors at the Broadway Auditorium, 9 a.m. to 9 p.m.; exhibit hall open from 9 a.m. to 10 p.m.; official opening of the mechanical exposition in Broadway Auditorium by Chairman Gilroy of the local convention committee at 7:30 p.m., with addresses by representatives of the National Exhibitors Association, Buffalo Chamber of Commerce, Manufacturers Association of Buffalo and President Felderman. Tuesday—Official opening of National Convention at 10 a.m., with an invocation by Rev. M. J. Ahearn and addresses of welcome by representatives of associations in Buffalo, President Felderman, Vice-President Holbrook and Past President Parry; afternoon session at 1:30 p.m. will be devoted to business and reports of various committees; evening session will be educational with papers, "Plant Maintenance," by Hon. T. Alfred Fleming, "Automatic Control of Fires," by Ira G. Hoagland, "Underwriters Laboratories Service to Engineers," by George B. Muldaur, followed by a film illustrating the talk and "How Do You Get Your Exercise," a sport pictorial film. The Wednesday morning session will be devoted to business and reports of committees; afternoon session to a welfare, paper and field day exercises. Thursday will have a business session in the morning, followed by a paper on "The Development of Mechanical Refrigeration," by Llewellyn Williams, of the Shipley Construction & Supply Co., New York City and W. A. Abbott, chief operating engineer, Commonwealth Edison Co., Chicago, Ill., will speak on the coal situation; the evening will be devoted to the Exhibitors entertainment. Friday there will be a final business session and the election of officers.

Thirty-Five Years an Editor

F. R. Low was tendered a testimonial dinner by his associates of the McGraw-Hill Company, Inc., at the Engineers' Club, New York, last Wednesday evening, to commemorate the thirty-fifth anniversary of his editorship of *Power*. Interesting reminiscenes were related by James H. McGraw and H. M. Swetland, who were publishers of the paper at the time Mr. Low assumed the editorship, and Calvin W. Rice, Secretary of the American Society of Mechanical Engineers, told of the faithful service which the guest of honor had rendered to the society over a period of thirty-five years, finally culminating in his selection as its president for the next year. A handsome loving cup was presented to Mr. Low as a token of the affection and regard of his associates.

Radio Talks To Be Given by McGraw-Hill Editors

From WJZ, New York, from 8:15 to 8:30 P. M.

Sept. 5—Earl E. Whitehorne, commercial editor, *Electrical World;* "Who Has More Slaves than Pharaoh," a talk on electricity.

Sept. 12—Kenneth H. Condit, editor, *American Machinist;* "Automatic Machines and Their Effect on Men."

Sept. 19—H. C. Parmelee, editor, *Chemical & Metallurgical Engineering;* "The Work of the Chemical Engineer."

Sept. 26—E. J. Mehren, editor, *Engineering News-Record;* "What Engineering Is and What It Is Not."

Verde River Project Combines Irrigation and Power

The Verde River Irrigation and Power District on Aug. 7 approved the issuance of $23,000,000 in bonds for constructing a dual irrigation and hydro-electric project. Plans contem-

plate the storage of 1,200,000 acre-ft. of water in two reservoirs and the development of 68,000 hp. in seven power plants according to the following distribution: 24,000 hp. operating under maximum head of 265 ft.; 3,700 hp. with maximum head of 90 ft.; 12,000 hp. with head of 292 ft.; 8,000 hp. with head of 190 ft.; 6,800 hp. with head of 145 ft.; 8,700 hp. with head of 175 ft.; and 4,900 hp. with head of 95 ft. The two reservoirs make it possible to develop about 200,000,000 kw.-hr. per year primary power, and there is also about 20,000 additional kw.-hr. per year secondary power that can be developed.

Recommends Exchange of Commercial Students

International exchange of commercial students is recommended by the foreign commerce department committee of the Chamber of Commerce of the United States in a report made public recently.

The committee points out that existing arrangements for foreign study are principally in connection with art, literature and the sciences, and that few organized facilities exist for the interchange of commercial students. Similarly, there is a lack of organized facilities for young business students in foreign countries to get any real practical contacts with business in the United States.

It is recommended that the foreign commerce department should give continuing attention to organizing facilities, and further recommended directly to American business concerns that they consider offering facilities for young foreigners to learn something about business in the United States and also offer facilities for young Americans to study business abroad. The report states that it is only when the officials of the individual business concerns in the United States take some real initiative for furthering such international student exchange directly, that American business can benefit from this movement.

Personal Mention

John E. Cunningham, Jr., has been appointed assistant manager of the production department of the Schenectady works of the General Electric Co.

F. Lee Townsend, formerly assistant boiler engineer at the Delaware Station of the Philadelphia Electric Co., has accepted a position with the Westinghouse Electric & Manufacturing Co. at the Philadelphia sales office.

Olaf E. Oleson, formerly president of the Edward Valve & Manufacturing Co., has severed his connection with that company and has associated himself as president with the Continental Valve & Equipment Co., 80 E. Jackson Boulevard, Chicago, Ill., manufacturers of and dealers in high pressure valves, fittings and auxiliary power plant equipment.

Coming Conventions

American Chemical Society, Dr. Charles L. Parsons, 1709 G St. N. W., Washington, D. C. Convention at Milwaukee, Wis., Sept. 10-14.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Electric Power Club, S. N. Clarkson, 900 B. F. Keith Bldg., Cleveland. Fall meeting at French Lick Springs Hotel, French Lick, Ind. Nov. 19-22.

Empire State Gas & Electric Association, Charles H. B. Chapin, Grand Central Terminal Bldg., New York City. Meeting at Lake Placid, N. Y., Oct. 8-9.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

Indiana Electric Light Association, T. Donahue, Northern Indiana Gas & Electric Co., Lafayette, Ind. Meeting at French Lick Springs, Ind., Sept. 26-29.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Pennsylvania**, at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York**, at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers; Herbert Smith, Room 211, Robson-Prichard Bldg., Huntington, W. Va. Third annual convention at Frederick Hotel, Huntington, W. Va., Oct. 19-20.

L. M. Smith, formerly assistant chief engineer of power houses for the Tennessee Coal, Iron & Railroad Co., Ensley, Ala., has resigned to take a position in the engineering department of the Alabama Power Co., Birmingham, Alabama.

Business Notes

The Walsh & Weidner Boiler Co., 11 Broadway, New York City, announces that Harold P. Brangs, who has had many years experience with water-tube boilers is now connected with its sales department.

The Huhn Manufacturing Co., maker of metallic packing, announces that A. R. Neff has been appointed its West Coast manager, with offices at 3 Ferry Dock, Seattle Wash., and 2 West Seventh St., Long Beach, Calif.

The General Electric Co., announces that Dr. Thomas Addison, who has been with the company for 33 years and who has been its Pacific Coast manager since 1892, has retired at his own request and will be succeeded by J. A. Cranston, formerly Northwestern manager.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 20, 1923	Aug. 27, 1923
Pool 1,	New York	$2.90@3.25	$3.00@3.50
Smokeless,	Columbus	2.75@3.25	2.75@3.25
Clearfield,	Boston	2.00@2.75	1.90@2.50
Somerset,	Boston	2.25@3.00	2.25@2.75
Kanawha,	Columbus	1.75@2.00	1.75@2.00
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	2.00@2.10	2.10@2.15
Franklin, Ill.	Chicago	2.75@3.00	2.75@3.25
Central, Ill.	Chicago	2.00@2.25	2.10@2.35
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.65@1.85	1.95@2.05
S. E. Ky.,	Louisville	1.50@2.25	1.50@2.25
Big Seam,	Birmingham	3.40@3.65	1.75@2.15

FUEL OIL

New York—Aug. 30, light oil, tank car lots, 28@34 deg. Baumé, 3⅜c. per gal.; 36@40 deg. 4c. per gal., f.o.b. Bayonne, N. J.

Chicago — Aug. 15, 24@26 deg. Baumé, $1.81½@1.86½ per bbl.; 32@36 deg., $2.01½@2.06½ per bbl., tanks cars.

St. Louis—Aug. 28, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.80 per bbl.; 26@28 deg., $1.85; 28@30 deg., $1.90; 32@36 deg., gas oil, $2; 36@40 deg., distillate, $2.20@2.25.

Pittsburgh—Aug. 24, f.o.b. local refinery, 30@34 deg., fuel oil, 4⅛c. per gal.; 36@40 deg., fuel oil, 4¾c.; 34 deg., neutral 7c.

Dallas—Aug. 25, f.o.b. local refinery, 26@30 deg., $1.36 per bbl.

Cincinnati—Aug. 28, tank car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¼c. per gal.; 30@32 deg., 4½c.; 38@42 deg., distillate, 5¾c.

Philadelphia—Aug. 24, 26@28 deg., $2@2.10 per bbl.; 16@20 deg., $1.78@1.85; 14@16 deg., $1.60@1.66½.

New Plant Construction

PROPOSED WORK

Ark., Hot Springs—The Baptist Church, c/o W. Cooksey, Vice Pres., 722 Garland Ave., plans to build a 5 story hospital. Estimated cost $2,000,000.

California — The state is having plans prepared for the construction of additional buildings at six state hospitals. Estimated cost $700,000. B. G. McDougall, Forum Bldg., Sacramento, Archt. Equipment detail not reported.

Calif., Blythe — The Southern Sierras Power Co., Pacific Finance Bldg., Los Angeles, plans to build a power plant on Mill Creek in the San Bernardino mountains, near here. Cost will exceed $250,000.

Calif., Los Angeles—The Bd. Educ. will receive bids until Sept. 7 for the construction of a 2 story auditorium, domestic science building and boiler plant for Hollywood school. Cost will exceed $150,000. N. F. Marsh, Broadway Central Bldg., Los Angeles, Archt.

Calif., Los Angeles—The Central Investment Co., 5006 South Vermont St., is having plans prepared for the construction of a 12 story apartment house on Grand Ave. Schultze & Weaver, Pacific Mutual Bldg., Los Angeles, Archt. Equipment detail not reported.

Calif., Los Angeles — The Graystone Apartment Co. is having plans prepared for the construction of a 14 story, 140x200 ft. apartment house on Sycamore Ave. Estimated cost $1,500,000. Curlett & Beelman, Union Bank Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Los Angeles—The Los Angeles Gas & Electric Co., 645 South Hill St., will issue $4,000,000 bonds for improvements and extensions to plant and equipment.

Calif., Los Angeles—D. M. Morris, c/o H. G. Johnson, Archt., 301 Pacific Finance Bldg., is having plans prepared for the construction of a 13 story apartment house on Wilshire and Catalina Sts. Equipment detail not reported.

Calif., Los Angeles—N. Talmadge is having plans prepared for the construction of a 10 story, 130 x 150 ft. hotel on Wilshire Blvd. and New Hampshire St. Estimated cost $800,000. Walker & Eisen, Pacific Finance Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., Oakland — St. Mary's College, Broadway and Hawthorne Sts., is having preliminary plans prepared for the construction of a group of college buildings on Foothill Blvd. Estimated cost $2,000,000. J. J. Donovan, Tapscott Bldg., Oakland, Archt.

Calif., Oroville—The Pacific Gas & Electric Co., 445 Sutter St., San Francisco, will expend $60,000 for improvements to gas, water and electric systems, here.

Calif., San Francisco—Meyer & Johnson, Archts., 742 Market St., are receiving bids for steel work of a 13 story store and club building on Post St. between Powell and Mason Sts. for the Elks' Club, c/o Archts. C. H. Snyder, 251 Kearny St., San Francisco, Engr. The general contract has been awarded to the R. McLeran Co., Hearst Bldg. Total estimated cost $1,000,000. Equipment detail not reported.

Calif., San Mateo—The City Trustees, E. W. Foster, Clk., will receive new bids for the construction of a pump chamber and installation of two 6 in. sewer pumps and equipment. Former bids rejected. Estimated cost $4,260.

Calif., Santa Ana—M. E. Durfee, Archt., Kraemer Bldg., Anaheim, representing owners, is preparing plans for the construction of a 10 story store and office building on 4th and Bush Sts., here. Equipment detail not reported.

Conn., Hartford—The High School Com. received bids for the construction of a high school on Maple Ave. from the H. Wales Lines Co., 134 State St., Meriden, total contract, Wheeler system of ventilating $1,587,000; total contract, recirculating system of ventilating, $1,619,792. Noted July 24.

Fla., Crescent City—The Bd. of Trustees will receive bids until Sept. 17 for a waterworks system, including 40,000 gal. reservoir, steel tank, tower and complete pumping equipment consisting of three motor pumps and two service pumps. Estimated cost $30,000. G. A. Main, Daytona, Engr.

Fla., Jacksonville—N. L. Bedford and associates, United States Trust Bldg., is having plans prepared for the construction of a hotel. Estimated cost $500,000. Greely & Benjamin, Bisbee Bldg., Jacksonville, Archts. Equipment detail not reported.

Fla., Lake Worth—The city, A. Drake, Mayor, is issuing $65,000 bonds for extension to electric light and water plant.

Ill., Rockford—The Standard Dairy Co., 1532 2nd Ave., is in the market for refrigeration machinery, pasteurization equipment, etc.

Ind., South Bend—The Bd. Public Wks., City Hall, will receive bids until Sept. 19 for the construction of a 73 x 104 ft. building, including concrete foundation and floors, estimated cost $154,000; 18 x 48 ft. concrete suction well, $30,000; 5 x 150 ft. chimney, $9,500; two 5,000,000 g.p.d. Corlis pumping engines and pump room auxiliaries, $65,000; two 150 hp. 200 lb. water tube boilers with superheaters and boiler room auxiliaries, $23,000; coal and ash storage and handling equipment, $12,500. J. W. Toyne, Engr.

Kan., Dresden — The city will hold an election Sept. 10 to vote $22,500 bonds for electric power plant, pole lines, engines, etc.

Kan., Kansas City—The city, H. Payne, Clk., plans election to vote $4,000,000 bonds for extension to water and electric light plant.

Ky., Louisville — The Louisville Gas & Electric Co., 311 West Chestnut St., is having plans prepared for extensions and improvements for steam power plant on river front, to increase capacity to 120,000 hp. New boilers will be purchased. Estimated cost $500,000. L. F. Strang, c/o owner, Engr.

Ky., Louisville—D. X. Murphy & Bros., Archts., Louisville Trust Bldg., will receive bids until Sept. 10 for the construction of an infirmary building on Preston St. and Eastern Parkway for St. Joseph's Infirmary, 4th St. Estimated cost $1,500,000. Equipment detail not reported. Noted July 10.

La., Washington—A. J. Miller, Mayor, and Bd of Aldermen will receive bids until Sept. 17 for the construction of electric light system, including one 250 kw., 2,500 volt 3 phase, 50 cycle a.c. generator, direct connected to oil engines; switchboard; oil storage tank; motor driven vertical type service pump for water supply with pumping pit; transformers; station house.

Md., Baltimore—The Bernheimer-Leader Stores Co., Howard and Lexington Sts., is having plans prepared for the construction of an 8 story, 122 x 156 ft. department store. Estimated cost $1,500,000. Smith & May, Calvert Bldg., Archts. C. L. Reeder, 916 North Charles St., Consult. Mechanical Engr. will purchase heating and ventilating apparatus. Noted Aug. 7.

Md., Baltimore — The Mayor and City Council, City Hall, plan to build a 6 story, 90 x 370 ft. police building on Fallsway, Lexington, Harrison and Fayette Sts. Estimated cost $700,000. Engineer or architect not selected.

Md., Baltimore — The Mayor and City Council, City Hall, are having plans prepared for the construction of a 4 or 5 story high school on Pulaski Ave., estimated cost $1,000,000, J. E. Sperry, Calvert Bldg., Archt.; 4 story schools at Hamilton, Walbrook and Arlington, $450,000 each, C. N. Fritz, Lexington Bldg., Archt.; 4 story school at Canton, $500,000, Wyatt & Nolting, Keyser Bldg., Archts.; 4 story school at Roland Park, $500,000, E. L. Palmer, Jr., 513 North Charles St., Archt.; 4 story school at Rognel Heights, $450,000, W. G. Beecher, 12 East Pleasant St., Archt.; 3 story school at Irvington, $400,000, H. Sill, 12 East Pleasant St., Archt.; 3 story addition to School 70 on Warren Ave., $300,000, O. G. Simonson, Inc., Hearst Tower, Archt.; 3 story addition to School 13 on Patterson Park Ave. and McElderry St., $300,000, R. P. Allen, 3 East Lexington St., Archt.; 3 story addition to school on Pimlico Rd., $300,000, J. E. Laferty, 13 West Mulberry St., Archt. Engineers not selected. Equipment detail not reported.

Mass., Brighton (Boston P. O.)—The city of Boston, Schoolhouse Dept., is having plans prepared for the construction of a high school, here. Estimated cost $1,200,000. O'Connell & Shaw, 134 Newberry St., Boston, Archts. Equipment detail not reported.

Mich., Detroit—The City Water Board received bids for furnishing and erecting a 37,000,000 gal. capacity reciprocating steam driven pump from the Worthington Pump & Mchy Co., 115 Broadway, New York, $247,700; Allis Chalmers Mfg. Co., West Allis, Milwaukee, Wis., $266,500; Bethlehem Steel Co., Bethlehem, Pa., $296,500. T. A. Leisen, Water Wks. Park, Engr.

Mich., Detroit—The Tuller Hotel, Park and Adams Ave., is having plans prepared for the construction of a 14 story, 60 x 106 ft. addition to hotel, including elevators on Bagley Ave. Steam heat supplied from main power plant. W. H. Adams, 32 Campau Bldg., Detroit, Engr. Noted Nov. 7, 1922.

Minn., Winona—The State Bd. of Control, D. F. Mullen, Secy., Capitol, St. Paul, will receive bids until Sept. 11 for the construction of a 3 story, 200 x 210 ft. main building, including power plant and steam heating system, for the State Teachers College, here. Estimated cost $550,000. C. H. Johnston, 715 Capital Bank Bldg., St. Paul, Archt. Noted Aug. 28.

Mo., Kansas City—The city is having revised plans prepared for a waterworks plant in addition to present plant, capacity 65,000,000 gal., on the Missouri River, also underground tunnel. Estimated cost $11,000,000. Fuller & Maitland, 201 Walsh Bldg., Engrs. Noted April 3.

Mo., Mountain Grove—The city holds an election Sept. 4 to vote on $35,000 bonds for the construction of an electric light plant, dynamos, switchboard, transmission lines, etc.

Mo., Republic—The city holds an election Sept. 4 to vote $35,000 bonds for electric light plant, transmission lines, power plant and distribution system.

Mo., Ridgeway — The city will hold an election Sept. 7 to vote $45,000 bonds for a waterworks and distribution system, including plant, pumps, engines, reservoir, distribution mains, etc. Shockley Eng. Co., 800 Graphic Arts Bldg., Kansas City, Engrs.

Mo., St. Louis—The United Rys. Co. of St. Louis, Park and 39th St., R. Wells, Receiver, has been authorized to expend during the balance of 1923, $212,000 for alterations and building shops and substations; $161,450 for substation equipment.

N. J., Newark—The Beth Israel Hospital, c/o F. Grad, Engr. and Archt., 245 Springfield Ave., is having plans prepared for the construction of a hospital. Estimated cost $1,200,000. Equipment detail not reported.

N. Y., Ballston Spa—The Bd. of Supervisors of Saratoga County is having plans prepared for the construction of a dam to store water to furnish 150 hp. for 100 days in low water, power house, 50,000 gal. storage tank, pipe line, generator, motors, etc., for Homestead Sanatorium, Saratoga County Tuberculosis Hospital at Providence. Estimated cost $50,000. E. E. Sheldon, 467 Broadway, Albany, Engr. Noted Aug. 28.

N. Y., Buffalo—The Tri-State Realty Co., Cleveland, Ohio, A. H. Bramson, Pres., plans to remodel the 5 story Hotel Iroquois on Main St., into a store and office building. Estimated cost $500,000. Equipment detail not reported.

N. Y., Jamestown—The city, L. Bergman, Engr. is in the market for a Babcock boiler with equipment, for proposed addition to Cassadagua water station. Estimated cost $12,000.

N. Y., Medina—J. C. Pesson and C. W. Grinnell plan to build a cold storage plant on Park Ave., to replace the one which was destroyed by fire. Estimated cost $50,000. The owner is in the market for chemical machinery.

N. Y., New York—The Bd. Educ., 500 Park Ave., is having plans prepared for the construction of a 5 story, 200 x 216 ft.

school building, including steam heating system, on Boynton Ave. and 172nd St. Estimated cost $2,300,000. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Engrs. and Archts.

N. Y., New York—The Dept. of Public Welfare, 10th Floor, Municipal Bldg., B. S. Coler, Comr., will receive bids until Sept. 7 for addition to refrigerating plant, also additions and alterations to the refrigerators at the City Home, Welfare Island.

N. C., Cullowhee—The Bd. of Trustees of Cullowhee Normal and Industrial School, is having plans prepared for enlargement of power plant. Estimated cost $40,000. H. A. Underwood, 916 Commercial Bank Bldg., Raleigh, Engr.

N. C., High Point — The Methodist Protestant College plans to build two dormitories, estimated cost $75,000 each, also a central heating plant, $28,000.

Ohio, Bellaire—The Imperial Glass Co. has had plans prepared for a 300 kw. generating unit to double capacity of its power plant. Contract has been awarded for engine and generator. H. O. Swoboda, Inc., Empire Bldg., Pittsburgh, Engr.

Ohio, Cleveland—The 1600 Prospect Co., c/o J. L. Free, 1004 Prospect Ave., plans to build an 8 story mercantile building, including steam heating system, on a 167 x 189 ft. site at 1600 Prospect Ave. Estimated cost $1,500,000. Engineer or architect not announced.

Ohio, Hamilton—The city, W. F. Mason, Dir. Public Service, is having plans prepared for an electric light plant. Estimated cost $650,000. Froelich & Emery Co., 412 2nd Natl. Bank, Toledo, Engrs.

Ohio, Painesville—The city is receiving bids for piping, switchboard, ash conveying machinery, boiler setting, breeching and temporary steel stack.

Okla., McAlester—The city, R. D. Ewens, Clk., will receive bids until Sept. 18 for waterworks improvements, including flow line, 1,000,000 gal. filters, filter and pump house, two 1,400 g.p.m. duplex power pumps, two 1,400 g.p.m. centrifugal pumps, 2,000,000 gal. concrete reservoir and c. i. pipe. E. T. Archer & Co., 612 New England Bldg., Kansas City, Mo., Engrs.

Okla., Paden — The city voted $25,000 bonds for electric transmission line, distribution system and pumping equipment, including a deep well pump. Grant & Baker, 1st Natl. Bank, Oklahoma City, Engr.

Okla., Ramona—The city defeated $50,000 bonds for mains, pumping equipment and well. Grant & Baker, 1st Natl. Bank Bldg., Oklahoma City, Engr. Noted Aug. 14.

Pa., Phila. — The Philadelphia Tyrians, 3320 North Broad St., are receiving bids for the construction of a 35 story, 50 x 200 ft. club house, including elevators. G. J. Reich, 5126 North 10th St., Engr. and Archt. Equipment detail not reported.

Pa., Sharon—E. E. Clepper, Engr., has prepared plans for a summer resort, including a dam, 1 mi. long, 45 ft. high, to create a lake, 1 mi. long, ¼ mi. wide; hotel, etc. Estimated cost $1,500,000. Owner's name withheld.

Pa., Williamsport—The Williamsport Hospital, 798 Louisa St., H. A. Mosser, Chn. Bldg. Com., plans to build a 3 story, 200 x 300 ft. addition to hospital on Campbell and Louisa Sts. Estimated cost $400,000. Engineer or architect not selected.

Tex., Beaumont—W. B. Dunlop and J. E. Fay, representing owners, are having plans prepared and will soon receive bids for the construction of a 4 story hospital. Estimated cost $300,000. Livesay & Wildeman, Houston, Archts. Equipment detail not reported.

Tex., Celina—The Fris-Co-Lina Utilities Co., c/o H. E. Blumberg, 1606 North Washington Ave., Dallas, is having plans prepared for the construction of additions to electric plant, also power line, here. Estimated cost $50,000. Private plans.

Tex., Galveston—The City Comn. will receive bids until Sept. 27 for one Ingersoll-Rand air compressor, 1,150 ft. capacity; one Knowles tandem compound pump, 4,000,000 gal. capacity; one low pressure duplex compound pump, 6,000,000 gal. capacity; condensors; piping, etc. C. A. Holt, Jr., Engr.

Wis., Green Bay—St. Joseph's Orphanage, Route 5, will soon award the contract for the construction of a 2 and 3 story, hospital, boiler house and laundry. Estimated cost $150,000. Faeller, Schober & Stephenson, Nicollet Bldg., Archts. The owner is in the market for power boilers, etc.

Wis., Milwaukee—F. Luber, Archt., c/o Milwaukee Electric Ry. & Light Co., 2nd and Sycamore Sts., is receiving bids for the construction of a 2 story, 52 x 70 ft. boiler house on Edison Ave. Estimated cost $65,000.

Wis., Milwaukee—The Sewerage Comn., 508 Market St., received bids for piping in power and boiler house in connection with sewage disposal plant on Jones Island from the Power Piping Co., 829 Beaver St., Pittsburgh, Pa., $47,300; Almirall & Co., 53 West Jackson Blvd., Chicago, $51,233; M. J. Dougherty Corp., 25th and Washington Sts., Phila., Pa., $54,000. T. C. Holton, c/o owner, Engr. Noted Aug. 21.

Wis., Sheboygan—The Wisconsin Public Service Co., c/o J. P. Pulliam, 559 Marshall St., Milwaukee is having plans prepared for the construction of a gas plant, including a storage tank, 138 ft. high, 128 ft. diameter, 1,300,000 cu.ft. capacity; boiler house with stack; pumping plant; high pressure gas mains; gas making machinery and equipment, here. Estimated cost $1,000,000. R. B. Brown, 182 Wisconsin St., Milwaukee, Engr.

Ont., Bothwell—C. Reid is in the market for a 12 x 12 cylinder steam engine.

Ont., London—The city is having plans prepared for the construction of storm and sanitary sewers, also pumping plant, including equipment. Estimated cost $300,000. W. P. Near, City Hall, Engr.

Ont., Walkerton—The City Council, F. B. James, Engr., will receive bids until Sept. 5 for the construction of steel stand pipe, 200,000 gal. capacity; two gasoline engines and pumps, 1,000 g.p.m.; three motor driven automatic pumps; c.i. pipe and fittings.

Ont., Windsor—The Essex Border Utilities Comn. is in the market for filtration strainer systems; c. i. pipe; valves; controllers; operation tables, etc.; four 10,000,000 gal. direct connected electrically driven centrifugal pumps with switchboard appliances; steel mains. J. C. Keith, Ch. Engr.

Que., Drummondville — The Southern Canada Power Co, 20 St. Nicholas St., Montreal, plans to build a power house, etc., to develop 30,000 hp. at Hemming Falls on the St. Francis River, near here. J. S. H. Wuretele, c/o owner, Engr.

Que., Montreal—The city plans an election to vote $2,500,000 for sanitary improvement of the Little St. Pierre River from Lachine to Montreal. Plans include deepening of the tail race from the mouth of the St. Pierre River to the St. Lawrence, estimated cost $75,000; construction of pumping station, $200,000; Section 1 from the tail race to Cote St. Paul Rd., $640,000; siphon under the Lachine Canal, $520,000; Section 2 from Cote St. Paul Rd. to Lachine, $1,100,000; also conduit to take under pressure the discharge from Westmount and Notre Dame de Grace, $530,000. G. R. McLeod, Engr.

Que., Notre Dame de Grace—The Homeopathic Hospital, 44 McGill College Ave., Montreal, plans to build a hospital, capacity 100 beds, here. Estimated cost $250,000.

Sask., Estevan—The town, A. B. Stuart, Clk., is in the market for an engine and generator for new electrical unit.

CONTRACTS AWARDED

Ark., Little Rock—The Missouri Pacific Hospital Assn., Railway Exch. Bldg., St. Louis, Mo., awarded the contract for the construction of a 4 story hospital, here, to the J. Stewart Co., Boatmen's Bank Bldg., St. Louis, Mo. Estimated cost $600,000. Equipment detail not reported.

Calif., Long Beach—The Bolivar Holding Co., c/o Curlett & Beelman, Archts., Union Bank Bldg., awarded the contract for the construction of a 14 story apartment hotel on East Ocean Ave. to the Scofield Eng. Co., Pacific Finance Bldg. Estimated cost $1,000,000. Equipment detail not reported.

Calif., Long Beach—W. Bradford, et al., c/o contractors, awarded the contract for plans and construction of an apartment house on Ocean Ave. to the Ransford-Gable Co., 1643 Highland Ave., Los Angeles. Estimated cost $1,000,000. Equipment detail not reported.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., awarded the contract for steel for the construction of a 70 x 100 ft. steam plant to be known as Sta. T on Stevenson St. near 6th St., to the Prode Iron Wks., 37 Hawthorne St., San Francisco. Estimated total cost $250,000. Noted Aug. 21.

Fla., Jacksonville—The City Comn., E. P. Owen, Jr., Secy., awarded the contract for the construction of extension of Talleyrand Ave. generating station to Gerbrich & Haugard, $51,302; Enterprise St. substation to W. T. Hadlow, Baldwin Bldg., Jacksonville, $14,744; structural steel to the Virginia Bridge & Iron Co, Trust Co. of Georgia Bldg., Atlanta, Ga.; boiler brick work to the Rust Eng Co., Woodward Bldg., Birmingham, Ala., $20,650; soot blowers to the Diamond Power Specialty Co., Oakland and Caniff Sts, Detroit, Mich., $13,690; copper expansion joint for the turbine to J Oats & Son, 232 Quarry St., Phila., Pa. The Talleyrand Ave. plant will house the 15,000 kw. generator. Noted Aug. 14.

Fla., Miami—The Bank of Bay Biscayne awarded the contract for steel for the construction of a 12 story bank and office building to the Ingalls Iron Wks., 720 Ave. D, Birmingham Ala.; foundation to R. C. Miller, Miami. Separate bids are now being received for the balance of the work. Estimated cost $1,500,000. Weary & Alford Co., 1923 Calumet Ave., Chicago, Archts.

Ill., Chicago—H. Defrees, c/o Rapp & Rapp, Archts., 190 North State St., awarded the contract for the construction of a 6 story, 100 x 142 ft. office and sales room building at 401-409 Rush St. to the H. Erickson Co., 139 North Clark St. Estimated cost $500,000. Steam heating system will be installed.

Ky., Louisville—The office of the United States Engineer, P. O. Box 72, awarded the contract for furnishing one vertical centrifugal pump to deliver 7,000 g. p. m. against a head of 25 ft., for dry dock, to the Morris Machine Wks., Baldwinsville, N. Y. Estimated cost $1,210. Noted May 22.

Mich., Lansing — The Masonic Temple Assn., 213 South Capitol St., awarded the general contract for the construction of a 7 story, 100 x 165 ft. temple to the Reniger Constr. Co., 336½ East Michigan St., Lansing. $577,000. Equipment detail not reported. Noted June 19.

Mich., Ramsay—Oglebay, Norton & Co., E. W. Hopkins, Mgr., awarded the contract for the construction of a 1 story, 75 x 250 ft. power plant and machine shop to the Foundation Co., 120 Liberty St., New York. Estimated cost $600,000. The owner is in the market for power machinery, chain conveyors, hoisting machinery, etc.

N. Y., New York—L. Kemper, Engr. and Archt., 7529 Cass Ave., Detroit, Mich., awarded the contract for the construction of a hotel in the Times Square section, here, to the Lynch Constr. Co., 1 Pershing Sq., New York. Estimated cost $1,500,000. Equipment detail not reported.

N. Y., New York — The J. H. Taylor Constr. Co., c/o Delano & Aldrich, Engrs. and Archts., 126 East 38th St., will build by separate contracts a 14 story, 100 x 133 ft. apartment house on Park Ave. and 86th St. Equipment detail not reported.

Ohio, Cleveland—The Independent Towel Supply Co., 1822 Central Ave., S. Miller, Mgr., awarded the contract for the construction of a 1 story, 35 x 80 ft. boiler house to the W. Dunbar Co., 8201 Cedar Ave. Estimated cost $50,000. Noted Aug. 14.

Wis., Madison — The Chicago & Northwestern Ry. Co., c/o B. R. Kulp, 2015 South Blair St., awarded the contract for the construction of a 1 story, 50 x 104 ft. power house to the C. W. Gindele Co., 4217 Belle Plaine Ave., Chicago. Estimated cost $100,000. The owner is in the market for power machinery, etc. Noted Aug. 21.

Wis., Milwaukee—The city, Central Bd. of Purchases, awarded the contract for coal and ash handling equipment for Riverside pumping station to the Link Belt Co., 910 South Michigan Ave., Chicago, $44,800. Noted Aug. 14.

Wis., Milwaukee—The Milwaukee Elks' Lodge, W. F. Eichfeld, 208 City Bank Bldg., Secy. Bldg. Com., awarded the contract for the construction of an 8 story, 110 x 145 ft. temple on Mason and Marshall Sts. to the Raulf Co., 428 Grand Ave., Milwaukee. Estimated cost $1,500,000. Equipment detail not reported. Noted July 10.

Wis., Waukesha—Carroll College awarded the contract for a central heating plant to the Thomas Heating Co., 846 Grand Ave., Racine. Estimated cost $25,000. Smokeless firebox boilers, steam radiation system, air lines, etc., will be installed. Noted Aug. 14.